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OPERATIONAL PROBLEMS OF THE AIR TRAFFIC CONTROL RADAR BEACON SYSTEM. 1972 SEMINAR HELD AT THE SHELBURNE HOTEL, ATLANTIC CITY, NEW JERSEY, ON FEBRUARY 8 THROUGH 11, 1972

National Aviation Facilities Experimental Center
Atlantic City, New Jersey

April 1973

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THE 1972 SEMINAR ON OPERATIONAL PROBLEMS OF THE AIR TRAFFIC CONTROL RADAR BEACON SYSTEM

THE SHELBURNE HOTEL
ATLANTIC CITY, NEW JERSEY

FEBRUARY 8 THROUGH 11, 1972

DEPARTMENT OF TRANSPORTATION * UNITED STATES OF AMERICA *

APRIL 1973

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, N. J.

FOREWORD

The Seminar on Operational Problems of the Air Traffic Control Radar Beacon System (ATCRBS) was held at the Shelburne Hotel, Atlantic City, New Jersey, from February 8 through 11, 1972. It was conceived as a forum for the free exchange of information among operational and technical personnel concerned with ATCRBS and is the first seminar of its kind dealing specifically with ATCRBS problems. A series of five workshops were tailored to the current needs of the field establishment of ATCRBS by the Federal Aviation Administration.

Hosted by the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, the Seminar was attended full-time by some 85 persons of whom 26 have been cited herein as contributors to the proceedings. Engineers and technical personnel numbered 50; the other 35 attendees were air traffic control specialists.

During the seminar, participants were promised that details of the material covered by all the speakers would be published at a later date. This document, which responds to that promise, contains the detailed technical matter of the seminar.

Meanwhile, a "Summary Report of Seminar on Operational Problems of the Air Traffic Control Radar Beacon System" was prepared immediately after the Seminar by Joseph A. Fantoni and Joseph J. Scavullo, the Seminar Chairman. The Summary Report was released in March 1972. Copies were forwarded to all participants, to all Directors of FAA Regions, Services, and the Academy, to interested Chiefs of Offices in FAA, and to the U. S. Department of Defense.

Short biographical notes are also included to identify the speakers. The number listed with each biographical note also appears in parentheses near the author's name below the title of his speech contribution. Some of the discussion, which had been recorded continuously from the public address system, was extracted from the tapes. All the editorial work of preparing this document was done by Mr. Thomas E. Zurinskas of NAFEC, under the general guidance of Mr. Scavullo.

The opinions, statements, assertions, conclusions, or recommendations contained in this document are related only to the Seminar; they are not to be construed either as the official statements or as reflections of the views of NAFEC or of any other specific organization participating in the Seminar.

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16. Abstract

This Air Traffic Control Radar Beacon System (ATCRBS) Seminar was the first of its kind dealing specifically with ATCRBS problems. Personnel attended the seminar from management, research, maintenance and operational organizations of the Federal Aviation Administration. It was sponsored by National Aviation Facilities Experimental Center (NAFEC) and Systems Research and Development Service (SRDS). It was held February 8 through 11, 1972, at the Shelburne Hotel, Atlantic City, New Jersey. Papers presented by 26 attendees are reproduced along with partial transcripts from associated discussions. The subject material is arranged according to the following titles which correspond to the workshops of the seminar: Introduction, Broken Targets, False Emergency Alarms, Electromagnetic Interference, False Targets, Missing Targets and Fading.

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PREFACE

INTRODUCTION TO THE 1972 SEMINAR

"Before turning the meeting over to the Seminar Chairman, I would like to briefly review the background leading to our having this Seminar and touch on some of the objectives that we hope to achieve.

In the way of background over the past years, SRDS and NAFEC have actively participated in resolving field operational technical problems that have been brought to our attention. This has included on-site assistance to Regions, as well as the carrying out of related R&D activities. We on the R&D side of the house consider this type support to the field to be a prime responsibility. Requests for support have not been confined to a given technical area such as the ATCRBS. For example, on-site assistance has been provided in the development of ATC procedures and the resolving of facility environmental, communications, navigational aid, display and primary radar problems.

In the ATCRBS area, a series of operational and technical problems such as fading and missing targets, broken targets, and false targets have been identified by specific field facilities, at Chicago's O'Hare McCook Facility, Eastern Region's Trevose Site, at Los Angeles, Knoxville and down at White House, Florida. We have participated in resolving these problems and I should add that, in some cases, we are still actively engaged in trying to find solutions. In addition, we have been advised by other field facilities that similar problems exist and require attention.

During the course of our R&D laboratory work in the ATCRBS area and as a result of our working with the Regions on specific field problems, considerable experience and know-how have been gained. Likewise, certain Region facility personnel, and many are with us at this Seminar, have also had valuable experience in properly diagnosing the ATCRBS field problems, in applying fixes, and have gained a better understanding of the system characteristics. It soon became apparent that information exchange sessions would assist in passing on this experience and know-how in order that other field personnel, as well as we in R&D could benefit. Thus the Seminar idea evolved. Since the types of problems, ie, interference, loss of targets, reflections, etc., and the corrective action taken (at, let's say, the Eastern Region's Trevose Site) have direct application to a similar problem in another Region, it appears that with the proper level of information exchange certain problems could be resolved by field personnel without delay, recognizing, of course, that the requirements for providing direct R&D technical assistance could still arise in the future due to new, not previously encountered technical problems.

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If we leave this Seminar better equipped, insofar as our understanding of air traffic control radar beacon system characteristics, and the fixes that should be considered for facilities with certain operational technical problems is concerned, then the objective of this Seminar will have been met.

Without elaborating it is quite obvious that with the type of representation we have at this Seminar, numerous other benefits will be derived by the active participation of each and a free exchange of information. Many of you have traveled a long distance to be with us and I am sure your absence from duty is critical to your organization. I also hope your stay over the period of this Seminar is comfortable, it is made interesting and of benefit to you as an individual, as well as to your organization."

Joseph A Fantoni

Joseph A Fantoni
Chief, Surveillance Systems Branch
NAFEC

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BIOGRAPHICAL NOTES

INTRODUCTION

ATCRBS, PAST, PRESENT AND FUTURE

by Martin Pozesky, EM-20 (1)

As you already know, this seminar was undertaken to focus attention on the problems of the Air Traffic Control Radar Beacon System (ATCRBS) and on the means available for treating them. Since my address opens the discussion, I will review the past history, present status, and future of the ATCRBS in the National Aviation System.

The role of beacon for air traffic control began as an aid to radar in extending the range, assuring the coverage and facilitating the identification of individual targets. With a beacon system, clutter due to terrain could be avoided, all targets could be made about equally visible, whether the size of a Piper Cub or a Boeing 747, and identity of individual targets could be associated with the position and altitude data so as to complete a 3-dimensional display.

In the PAST, during World War II, beacon was developed first for identification of friendly aircraft. It operated in one mode involving two time-spaced interrogation pulses.

The ATCRBS was introduced by the mid 1950's with three modes of operation. The military Mode 1 contained enough pulses for identification by 32 different codes and Mode 2 contained provisions for 4096 identity codes. Both served the needs of military operations. Mode 3/A was adopted so that both military and civil transponders could operate in the civil traffic control systems where 64 identity codes had become available.

The PRESENT ATCRBS began with changes undertaken about 1964. It contains provisions for all the early modes but has added Mode C for acquisition of target altitude data and a secure mode, Mode 4, needed for other military purposes.

A national program was undertaken for upgrading the ATCRBS, both on the ground and in the air. AIMS was the acronym identifying this major joint effort of Department of Defense and Federal Aviation Administration.

AIMS = ATCRBS IFF MARK-X SYSTEM

Under their agreements, airborne transponders were provided the capability of replying to Mode C interrogations with altitude data, 4096 codes were made available in the identity replies to Mode 3/A interrogations and extraneous interrogations, via side lobes, were suppressed by incorporation of Side Lobe Suppression (SLS) modifications.

In the FUTURE, by the 1980's, ATCRBS is likely to evolve from a 5-mode system to the 8-mode Discrete Address Beacon System (DABS).

The added communications features should largely eliminate the synchronous garbling problem and help the DABS in meeting future traffic needs.

Thus, from a radar aid, ATCRBS has become the primary surveillance system on which todays air traffic control system must rely for the position, identification, altitude and tracking of targets.

If traffic were unrestrained, the analysis of statistical data indicates that by 1980 our air traffic will have doubled from the present, and by 1995, we could reasonably expect a five-fold increase.

Between 1963 and 1980, the number of general aviation aircraft will have increased four times and the number of air passengers by five times. Thus, upgrading to meet the demands for capacity and safety has become recognized as essential. Indeed, the pursuit of a superior ATCRBS has acquired the top priority within FAA.

Technical Events of the Past - The ATCRBS evaluation has been marked with a number of noteworthy technical events each rising to meet operational needs of the time. Perhaps foremost was upgrading of Mode 3/A so as to accommodate 4096 codes instead of only 64 codes. Next seems to be the addition of transponding and processing of Mode-C altitude data, SLS provisions eliminated much of the interference known as "ring around" while the later improved SLS offered extensive relief to problems of false targets due to reflection of beacon signals from structures near the interrogator.

ATCRBS has become the key sensor furnishing target position and identity under the automation program. The NAS Stage A equipment was first to introduce beacon data along with radar data while equipments bearing the nomenclature ARTS II, ARTS III and AN/TPX-42 make use only of beacon inputs.

Future Plans - The Electronic Scan Antenna is a principal new development to overcome false targets due to reflections, which are at present unavoidable because of the physical environment near operating sites. It will offer shaped and steerable radiation patterns under computer control of many radiating elements. With it, beams will be lifted over local reflectors and efforts of the ground or vertical lobing will be by-passed.

A number of mechanical changes to the present antenna system are being investigated and the extra feed horns are being tried within the same reflecting aperature along with the radar antenna feed.

Older processors of beacon replies are gradually being superseded by the solid state processors of which the ARTS and NAS Stage A ground stations are based. These processors are associated with new digital defruiters which are expected to overcome the maintainability limitations of older storage tube defruiters.

Monitoring of the beacon environment has been undertaken and policing has begun through the Beacon Management Team under OP-4. Specially instrumented vans and aircraft are under development for use in the surveillance of the operating ATCRB, analysis of its condition, and location of components. Regulations are being promulgated so that no longer is the environment uncontrolled. Tighter standards will improve the performance of airborne equipment,

especially the antenna systems. Meanwhile, new techniques such as Receiver SLS, Suppression, and Monopulse Antenna Operation are being pursued.

In the past, funding of R&D programs for ATCRBS has been limited as a matter of priorities, but starting in 1971, a great new increase of funds has brought the level from less than $1.0 Million to about $4.5 Million. (See Figure 1a.) Also limiting the past engineering and development support available in the past for ATCRBS has been manpower shortage. From 1960 up to 1971, less than 20 in-house man years were being expended for this purpose, but in 1971, the E&D Manpower increased to nearly 50 man years per year. To the expanded force at NAFEC, manpower has been added at the Department of Transportations Transportation Systems Center (TSC), at the Lincoln Laboratories of MIT, and at the MITRE Corporation. (See Figure 1b.)

The future of the ATCRBS, therefore, is bright with activity and promise. Attaining the new element of that future will be the result of joint efforts within the government as well as the continued support of its contractors. Keeping the system operating brilliantly will be the task of todays field forces. Figure 2 shows the main organizational elements on which that future depends. By their team action and by their individual efforts, we may expect new hardware new techniques, new capabilities and the success of the ATCRBS.

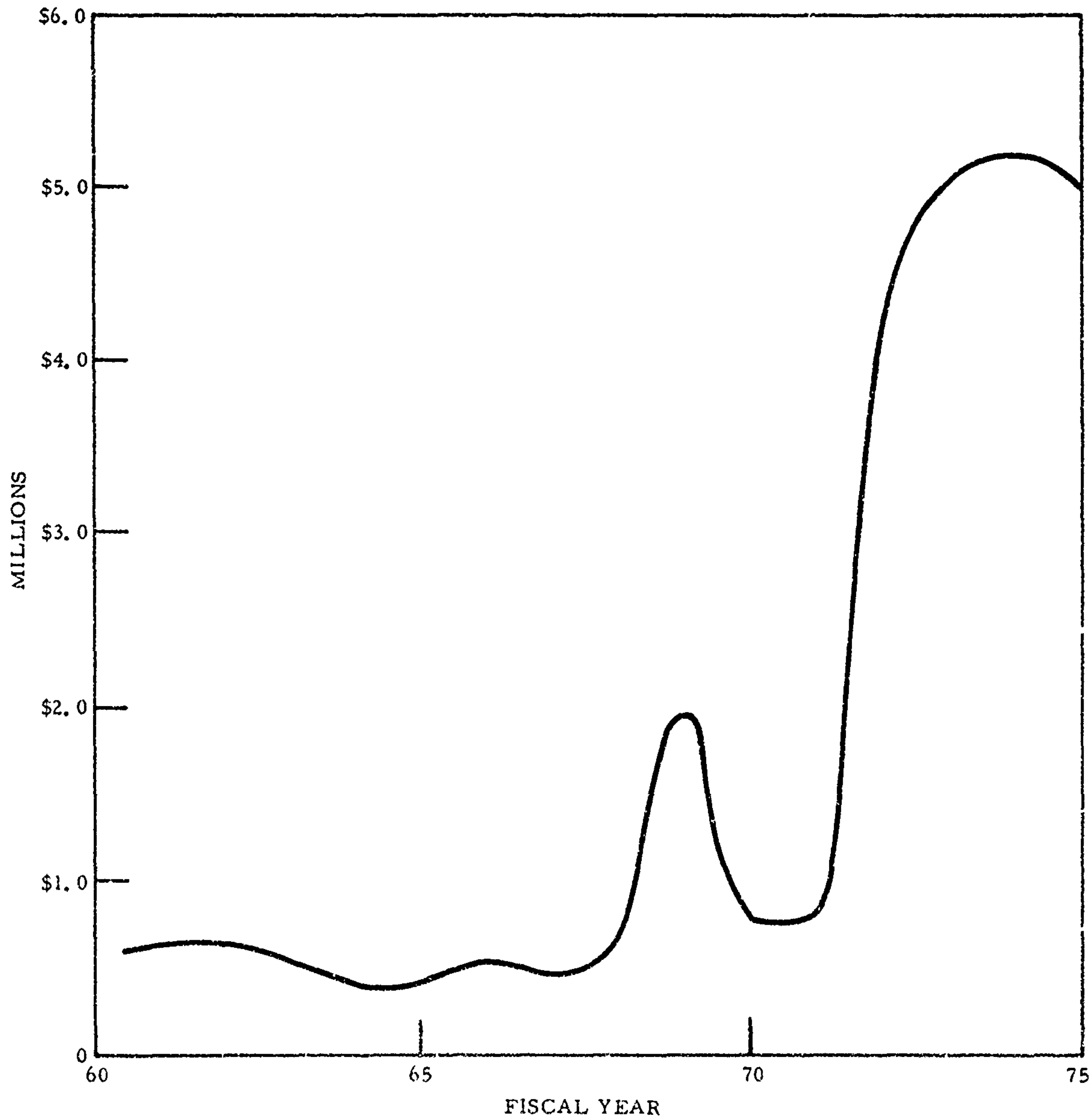


FIGURE 1a. HISTORY OF ATCRBS E & D FUNDS

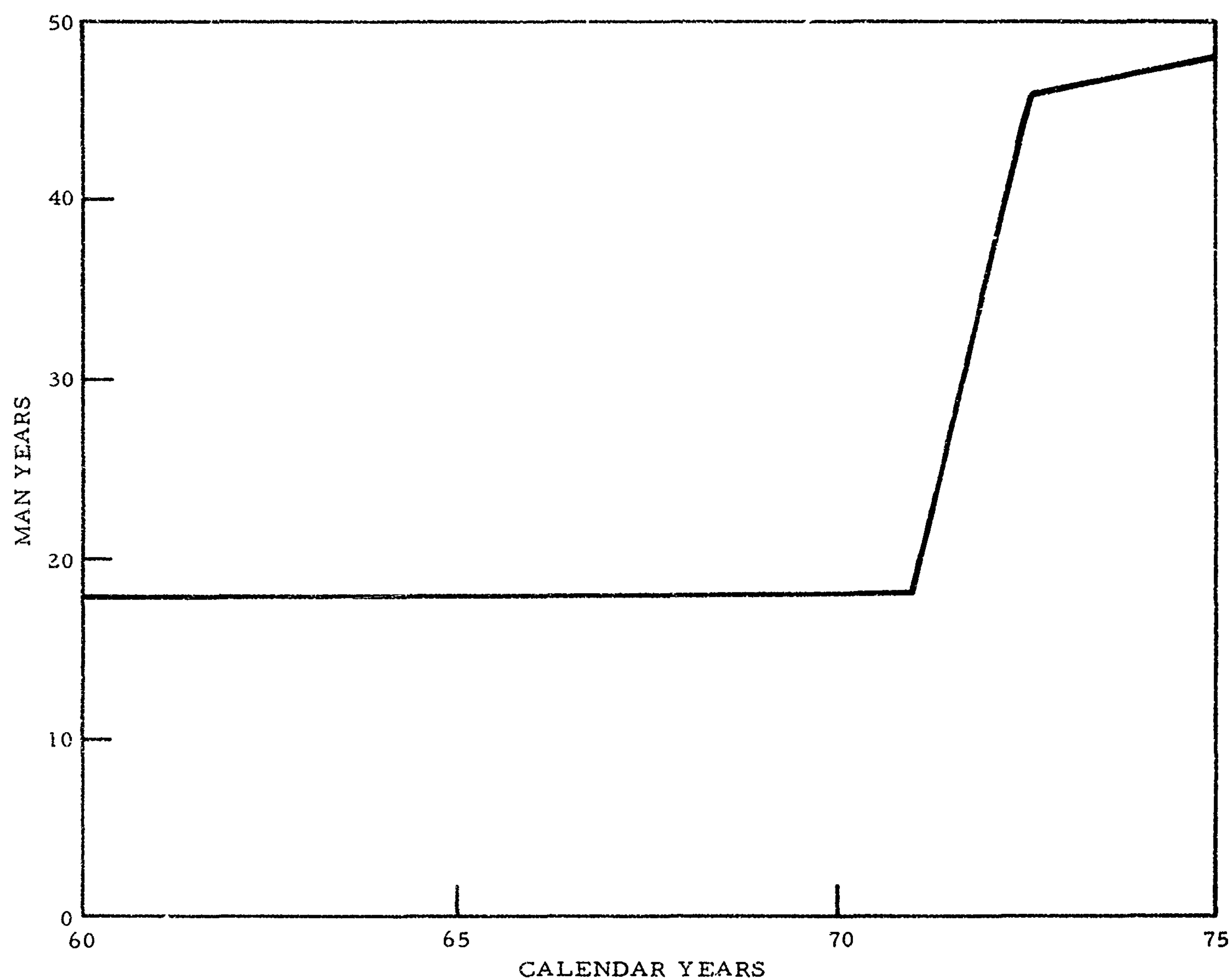


FIGURE 1b. HISTORY OF ATCRBS E & D MANPOWER

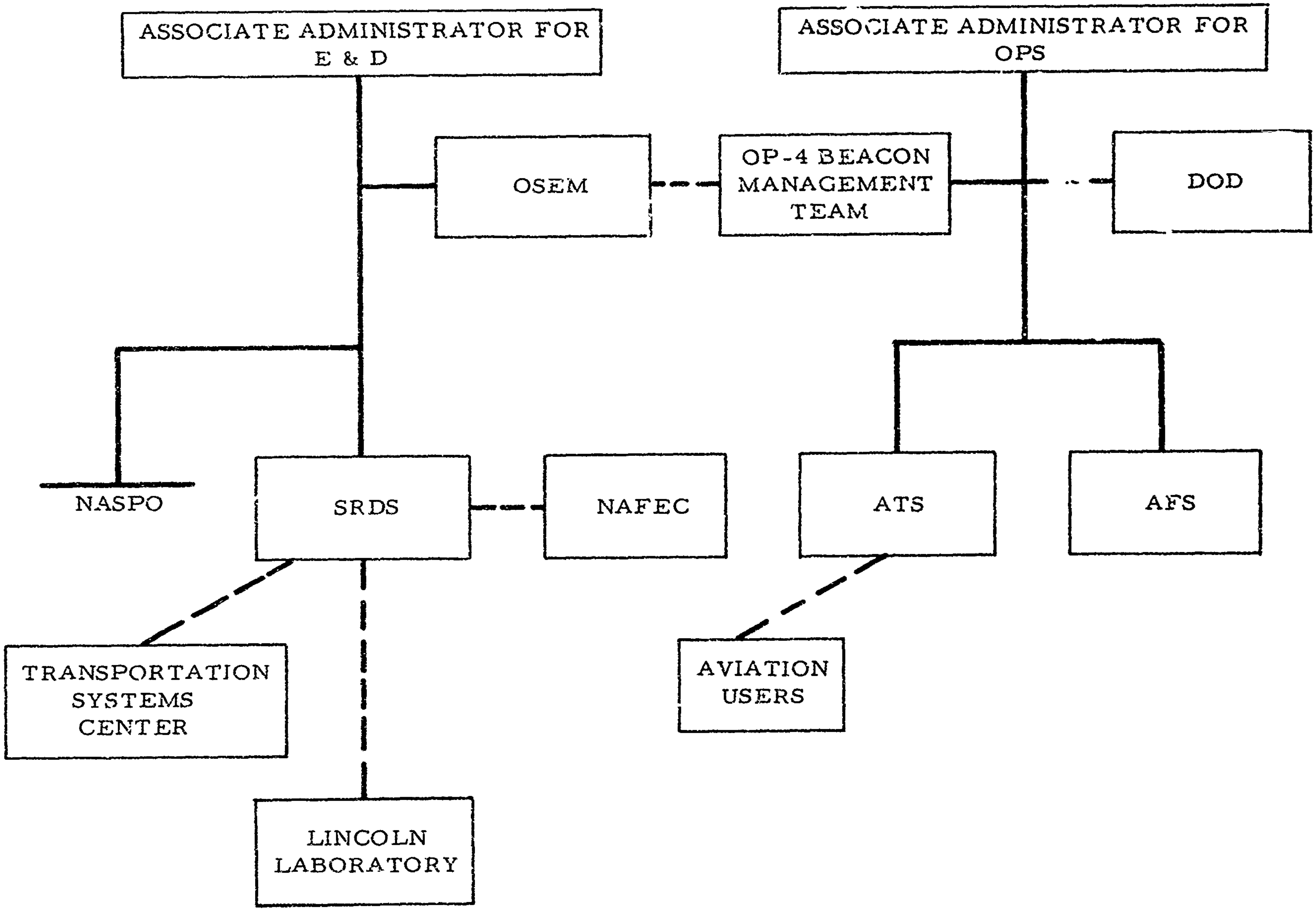


FIGURE 2. ORGANIZATIONAL ELEMENTS INVOLVED IN ATCRBS FUTURE

ATCRBS PROGRAMS FROM THE ATS VANTAGE POINT

by Larry L. Craig, AT-120 (2)

Speaking for Air Traffic Service, we welcome this opportunity for both Air Traffic Control and technical people to gather to discuss beacon problems.

Our management has placed the highest priority on getting the beacon problems fixed, and feel that the future of the whole air traffic control system hinges basically on our success in doing this.

This morning we'd like to show you that our present and future air control programs are related to beacon.

Transmitter Improvements.

Starting at the transmitter side of the improvements in air traffic control, the ATCBI-4 interrogator system is being delivered with single channel interrogators temporarily, due to the immediate demand for equipment (Table 1). Twenty-two of the total 65 systems are being delivered this way.

Most interrogators now are the ATCBI-4, it has improved side lobe suppression, and pretty much is a solid state version of the ATCBI-3.

The last of the 65 ATCBI-4's will be delivered by December of this year. Thirteen systems thus far have been delivered, and most of them are being installed at this very moment, however, I don't think any of them have been tried except but commercially.

We are attempting to make an additional buy of ATCBI-4's (Table 2), the money is available, however, we don't have the contract yet, and thanks to Joe Herrmann and the Beacon Management Team on the OP-4 part of the system - the RAPCOM went out to 16 locations.

As for the obsolete UPX-6 and UPX-1, single-channel equipment at RAPCOM ATC locations; 11 of these interrogators are being adapted to create a second channel for those ATCBI-4 that are being delivered. First delivery will take place about January 1973.

Jim Houton is here from AF. He's just finished writing the specifications for ATCBI-5, which is the next generation of interrogator, and speaks more specifically to requirements of long range radars. The advantage of the ATCBI-5 will be that it can be used at joint sites that meet the ATC requirements for beacon. Thus far, we have a program for 31 systems (Table 3). The funds are available, the first delivery is about 2 years from now. The specification is written for this program, it is not yet under contract.

Defruiters probably will be available at all terminal radar systems (ASR's) at State II or better (Table 4).

TABLE 1. ATCBI-4 DESTINATIONS

FAA Academy
Miramar, Calif.
El Toro, Calif.
Andrews, Md.
Washington (Nat.)
Oklahoma City, Okla.
Boston, Mass.
Lexington, Ky.
Columbia, S.C.
Ft. Lauderdale, Fla.
Dayton, Ohio
Oakland, Calif.
Chicago (O'Hare)
South Bend, Ind.
Omaha, Neb.
Dallas, Tex.
Columbus, Ga.
Beale, Calif.
Huntsville, Ala.
Raleigh-Durham, N. C.
JFK Kennedy, N.Y.
Atlanta, Ga.
Newark, N. J.
Monterey, Calif.
Erie, Pa.
Springfield, Ill.
Palmsdale, Calif.
Riverside, Calif.
Olathe, Kansas (ARSR)
Kirksville, Mo. (ARSR)
Hutchinson, Kansas (ARSR)
Pensacola, Fla.
Anchorage, Alaska
Tonopah, Nev. (ARSR)
Saginaw, Mich.
Chicago (South)
South Bend, Ind.
Omaha, Neb.
Dallas, Tex.
Chicago (South)
Charleston, W. Va.
Shreveport, La.
Mobile, Ala.
Providence, R.I.
Los Angeles, Calif.
West Palm Beach, Fla.
Las Vegas, Nev. (ARSR)
Mather, Calif. (ARSR)
Youngstown, Ohio
Tucson, Ariz.
Red Bluff, Calif. (ARSR)
Fort Wayne, Ind.
Kahului, Hawaii
Baton Rouge, La.
Peoria, Ill.
Cedar Rapids, Iowa
Green Bay, Wisc.
Billings, Mont.
Moline, Ill.
Lincoln, Neb.
Flint, Mich.
Rochester, Minn.
Midland, Mich.
Fort Smith, Ark,
Asheville, N.C.
Fargo, N.D.
Boise, Idaho
Sioux City, Iowa
Lansing, Mich.

TABLE 2. ATCBI-4 PLANNED ADDITIONAL CONTRACT

Oakdale, Penn. LRR	33 systems
Hanna City LRR	
Texarkana, Ark. LRR	
Omaha, Neb. LRR	
Oklahoma City, Okla. LRR	

Abilene	Rome
Great Falls	Savannah
Guam	Tacoma
Hyannis	Spokane
Macon	Fairbanks
Montgomery	Corpus Christi
Ogden	Lemoore
Oklahoma City	Meridan

NAFEC

11 for dual channel requirements.

TABLE 3. ATCBI-5 PROPOSED CONTRACT - 31 Systems

Lake Havasu City	Fallon
Marietta	Malmstrom
Whitehouse Field	Keno
Jedburg	Mica Peak
Oilton	Bucks Harbor
San Antonio	Patrick
Houston	Key West
Gettysburg	Tyndall
Alexandria	Benton
Hastings	MacDill
Amarillo	Kalispell
West Mesa	Empire
Fire Island	Aiken
San Pedro	Hartford
Boron	Richmond
Mt. Laguna	

TABLE 4. DIGITAL DEFRUITERS--FY 1973

11 Systems

Amarillo
Richmond
Charleston, S. C.
Jackson
Roanoke
Atlantic City
Chattanooga
Greenville
Burlington
Binghamton
Wilkes-Barre

RAPCOM's are also provided funds at certain locations listed, and these are included in the 1973 budget.

The AN/TPX-42.

To controller types, the term TPX-42 sound probably very alien, but it is a numeric beacon decoder at which we have contracted 26 of these systems. The first system has been delivered. Binghamton, N. Y. is the furthest along in installation, with one display completed (Table 5).

TABLE 5. AN/TPX-42(V)4 DESTINATIONS

Lexington, Kentucky	Monterey, California
Binghamton, New York	Sioux Falls, South Dakota
Columbia, South Carolina	Kahului, Maui, Hawaii
Amarillo, Texas	Fresno, California
Charleston, West Virginia	Springfield, Illinois
Little Rock, Arkansas	Baton Rouge, Louisiana
Madison, Wisconsin	Peoria, Illinois
Columbus, Georgia	Cedar Rapids, Iowa
West Palm Beach, Florida	Green Bay, Wisconsin
Youngstown, Ohio	Billings, Montana
Erie, Pennsylvania	Moline, Illinois
Augusta, Georgia	Lincoln. Nebraska
Grand Rapids, Michigan	Flint, Michigan

The TPX-42 provides a numeric readout on the controllers display of the 4096 beacon code, also the Mode C altitude readout. It has many other features, altitude feathering, discreet target symbols, emergency response for lost radio, and hijack, and its the latest generation of terminal decoding systems.

ARTS III.

For the medium and the high activity locations, we're talking about the ARTS III program. There are 61 operational systems under contract. Additionally the Academy, NAFEC and the test bed have systems. Thus far, 30 of these have been delivered. Two are operational - Chicago and Denver, and 19 total systems are now at initial operating capacity. Sixteen of these are AT, and the other three are RD systems - plus the test bed at NAFEC.

The NAS Stage A system has planned the first center to go operational - Los Angeles, and the antenna and EIC are at initial operating capability.

The 20 Channel Modification.

Probably the most unpopular beacon program from the controller point of view right now is called the 20-channel modification. To explain this for just a minute:

In 1962 a decision was made in the high national levels of the FAA, not to buy any additional beacon decoder equipment. The rationale was that by 1967, NAS Stage A would be coming along, and a massive amount of decoders would become available. In the meantime, requirements changed whereby minimum requirement for all systems now includes 4096, and Mode C numeric readout. The ATCBI-1 or the ATCBI-3 system didn't meet our requirements either.

The NAS Stage A program has suffered some slippage that puts it back into 1974 time frame (Figure 3). So from 1969, a policy was formed for the interim in order to meet expansion requirements, and have beacon decoders.

The Western Region had designed a device called the 20-channel modification, which enabled you to take 3 non-common decoders, with a common equipment, and expand up to 25 operating positions, with a position selection box. It was realized that this would create some restraint, but is was the only way we could go within the existing time frame. However, the air traffic service total requirements nearly doubled at the time this was under contract.

The restraints on the system are these; that you can't run more than 20 codes selected on any one radar system at a time, and you can only pool-select 12 of those 20 codes at each position.

In order to allow these particular centers to meet their expansion requirements, we proceeded with the program. AT is aware of the constraints of this system, and are working with the contractor, and the depot in an attempt to come up with more utility in this system. We hope to do it through the form of a code slaving modification that would allow more than one code in each position.

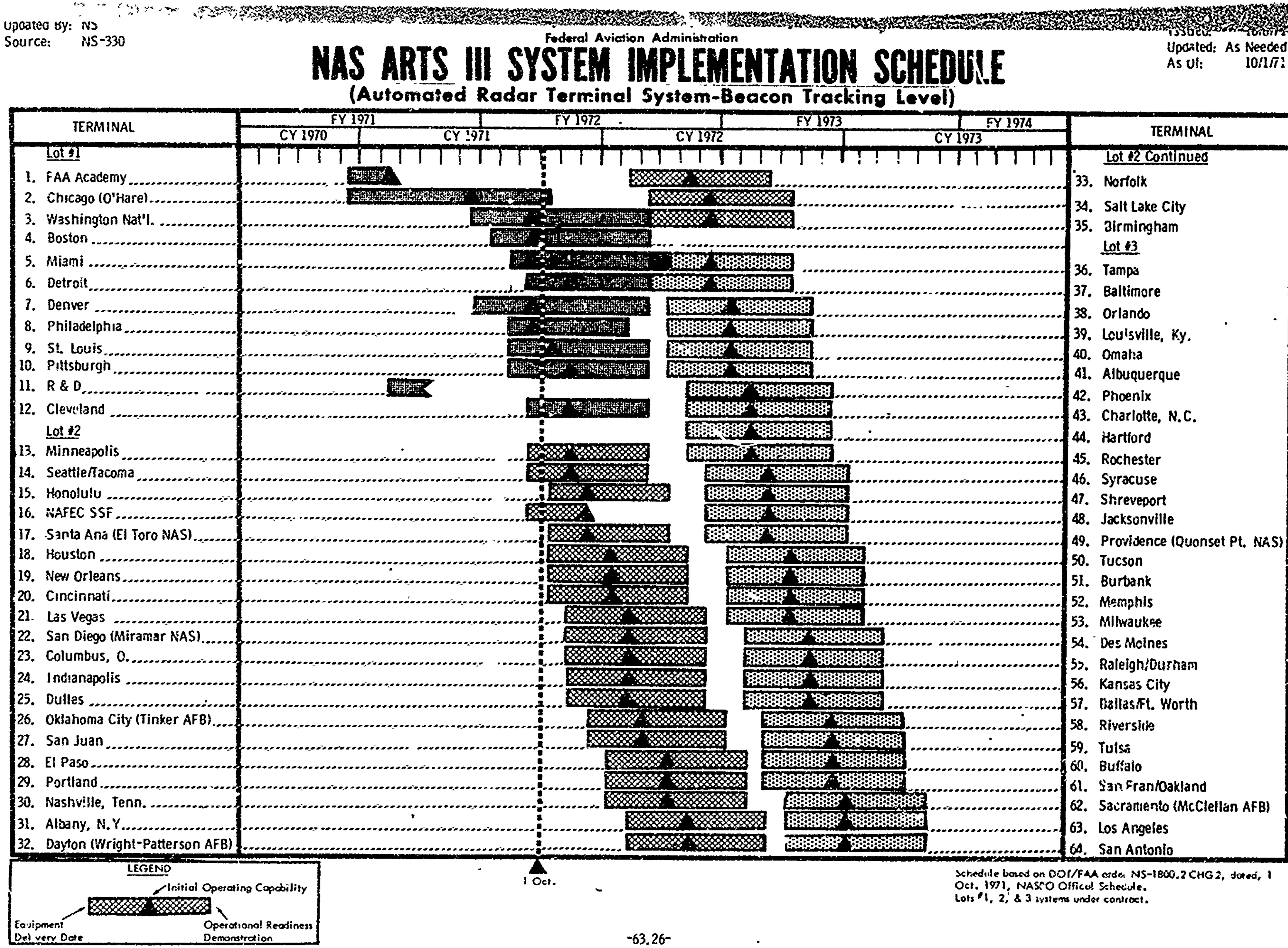


FIGURE 3. NAS ARTS III SYSTEM IMPLEMENTATION SCHEDULE

The Three-Slash Model.

About a year and a half ago, the keep-em-high policy came out of Air Traffic Service in an effort to reduce the exposure of large turbojets, and transport carrier airplanes, to the smaller airplanes. This policy expanded what the requirements were for equipment. A small terminal increased its allocated airspace from 3000 feet to 10,000 feet, and consequently picked up a great deal of en route traffic.

Through efforts by the Southern Region, a device called the three-slash model was developed for both the ATCBI-2 and ATCBI-3 decoder systems. This device is designed to allow the one thumbhead position on the 12-12 type decoder, to be modified so that the code selected at that position, instead of responding with a one- or a two-slash responder, is a three slash, and the controller can identify that airplane as being one that is an overflight, or something that transgresses several vectors.

To date the ATCBI-3 electronic engineering modification has been sent to field facilities. The ATCBI-2 should be out hopefully, within 2 weeks. 'Its a joint effort between the AT facility chief, and the AF sector manager, to determine what the local facility requirements are in requisitioning equipment from the depot - the place where it's manufactured.

The application of the three-slash to en route traffic is being explored, and the Great Lakes Region just came in and requested that Indianapolis be used as a test bed for this. Hopefully within a couple of months we'll have some input from Indianapolis to decide whether or not this could have a good application to the en route system.

ARTS II.

In our 1973 budget, we have an item called "replace-obsolete decoders" (Table 6). These, other than Fort Wayne, Indiana, represent all RAPCOM and RASY facilities that have the AN/UPX-1, -6, -9, and -24 equipments. These equipments are to be replaced. Quite frankly, a decision has not been made as to what will replace that equipment. The two prime candidates are the TPX-42, and the ARTS II system, which I'll talk about now.

In the FY74 call, which is now coming back from the regions, identifying requirements to Washington, we've included a national field item called ARTS II, twenty-three locations (Table 7).

ARTS II was proved in Knoxville, Tennessee. It is very similar to ARTS III but it does not include beacon tracking, or ground speed readout, but is a primary function of it.

TABLE 6. REPLACE OBSOLETE DECODERS—FY 1973

19 Locations

Anchorage	Meridan
Austin	Mobile
Abilene	Ogden
Fairbanks	Palmdale
Fort Wayne	Pensacola
Guam	Rome
Great Falls	Spokane
Hyannis	Tacoma
Lemoore	Montgomery
Macon	

TABLE 7. FUTURE PROGRAMS ARTS II FY 1974

23 Locations

Academy	Jackson
Wichita	Reno
Greensboro	Atlantic City
Toledo	White Plains
Charleston, S. C.	Akron
Corpus Christi	Harrisburg
Lubbock	Wilkes-Barre
Richmond	Greenville
Huntsville	Briston
Albrook	Chattanooga
Colorado Springs	Roanoke
South Bend	

ARTS II component package is soon to be tested at Wilkes Barre, Pennsylvania, and hopefully from that test, R&D will define exactly what the functional capabilities of ARTS II are, and what the equipment requirements are. Basically, it will be a minicomputer low activity ARTS III system. The specifications for ARTS II components should be available in FY 1974 - about the same time the money will become available.

Future Transponder Requirements.

We've been trying for many years to get an operational rule out to make the minimum requirement for transponders 4096, Mode C in certain areas. We are persuing this, and we have been instructed to put out a supplemental that we intend to require 4096 and Mode C in TCA area and in designated terminal areas in 1974.

The designated terminal areas in our minds eye are probably ARTS III facilities. However, in every case its going to require rule making action on an individual basis. So we're talking about 61 ARTS III locations of which eight or nine will be TCA's, so its going to be a long involved process to get this done.

By 1975 we're saying that 4096, Mode C, will be a requirement for about 12,500 or 3,000 feet above the terrain, whichever is higher.

Present Transponder Population.

To put things in perspective, I'd like to show the status, as we understand it to be, of the transponder population (Figure 4).

The air carrier fleet is nearly 100 percent equipped with 4096 and Mode C altitude reporting.

The military have approximately 4,000 airplanes at this time with this capability. However, they have a very ambitious program to retrofit with Mode C, and they hope to complete this by 1974.

General aviation has probably surprised most of you because today approximately 45,000 general aviation airplanes are equipped with 4096. It is estimated that about 3,000 have Mode C. All of them advocate the desirability of having it.

This is our present and future programs. Things can change, but this is what we're attempting to do.

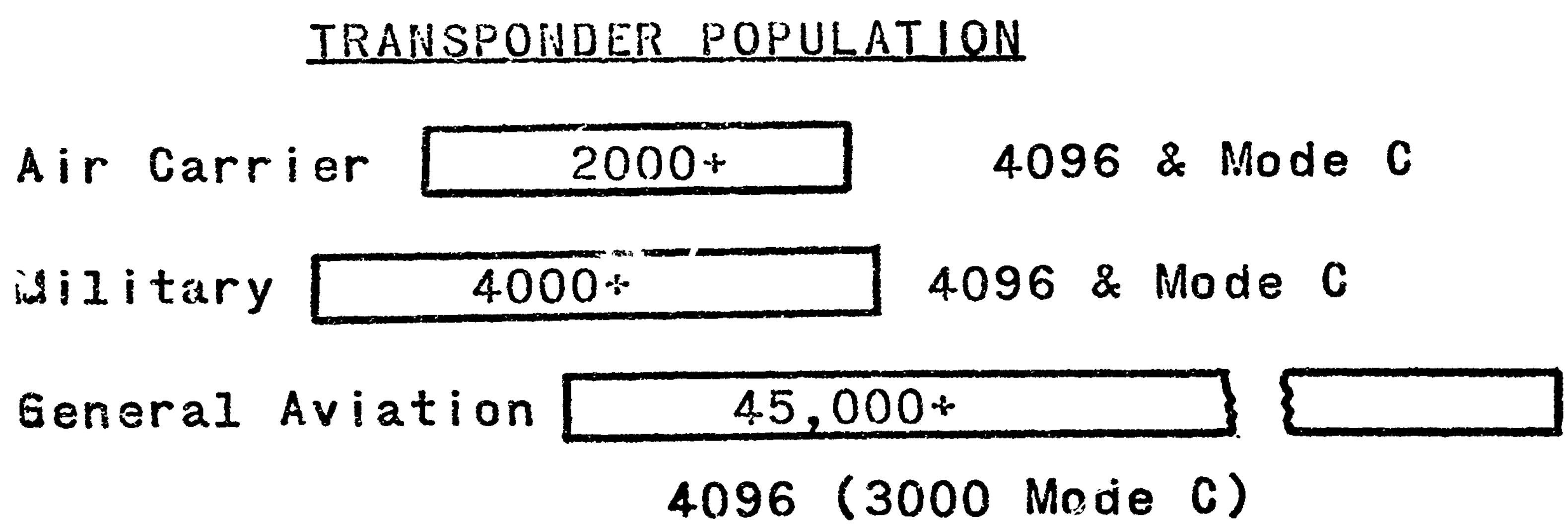


FIGURE 4. TRANSPONDER POPULATION

THE NUMBER OF MILITARY FACILITIES TO CONVERT TO AIMS

by Lt. Col. Alan N. Good, USAF, OP-4 (3)

DOD is very grateful to be invited to this seminar. We hope to learn quite a bit from it.

AIMS.

AIMS is an acronym of acronyms, as most of you know by now. The A stands for ATCRBS; the I stands for IFFSIF, the M for Mark X, which is limited to the military; and the S is for System.

I would like to give you the DOD program as far as AIMS is concerned.

In the DOD management effort, one of our subjects has been a generation of a DOD/FAA program review. We've had one of these meetings so far in January, and the FAA and DOD gave an overview of what their installation programs were. We hope this will have a favorable impact on the implementation of the full ATCRBS program.

DOD Program.

Here I have put together a summary of the DOD program.

Starting with the Army, they will be putting AIMS equipment in 8,000 aircraft, of which 5,000 will be stationed within the continental United States. All aircraft in the Army inventory will have AIMS equipment by 1974, except for some others which will take till 1976.

The ground program consisting of 114 air defense interrogators, at the RAPCON sites are scheduled for TPX-46 equipment by June 1973. Also, 27 air fields operated by the Army have TPX-41 equipment which are AIMS compatible, and Ft. Rucker has three ATCBI-3's, and three TPX-44 interrogators, which rounds out the Army program.

The Navy total inventory of aircraft is 9,000 made up of 6,000 operational at anytime under present DOD ceilings. Eighty percent of these aircraft will carry AIMS by January 1973.

The Navy has 1,673 Navy aircraft with airborn interrogators. The Navy also has a ground program. One hundred of their operation air traffic control sites will be AIMS equipped. Of these, 60 will have the TPX-43 equipment.

The Navy has 27 training sites with 131 interrogators. All these will be replaced with AIMS equipment.

The Navy has ramp test sites, which is a third parameter in the system. There are 72 sites, 398 of these will be replaced by AIMS equipment.

The Air Force will retrofit approximately 11,300 aircraft with AIMS equipment. There will be 1,500 airborn AIMS interrogators.

All RAPCOMs and GCA's will be replaced by the TPX-42 by December of 1974 hopefully.

The category II testing of the TPX-42 is now under process at Alice Air Force Base in Oklahoma. By July of this year we expect to have four operational TPX-42's, with an additional 20 in some phase of the installation.

There will be more than 400 ramp test sites to be replaced with AIMS equipment.

We have a third portion of the Air Force - the Air Defense Command. SLS has been installed at approximately 78 of 99 Air Defense Sites.

Summary.

To summarize this as far as the DOD/AIMS program is concerned, we have 29,000 aircraft which will be retrofitted: 538 ground sites, including the Air Defense functions, and the air traffic control sites, 266 ships will have AIMS equipment; 100 ramp test sites will have AIMS. The DOD is really involved in AIMS equipment, and the money involved is approaching one billion dollars.

EUROPEAN OPERATION OF ATCRBS

by Alton M. Waldin, EU-560 (4)

I understand that foreign languages are verboten, so we won't try to get into those.

I must warn you that a little of this discussion we have today may sound like there is some foreign language in it because we did have some indication that you might be interested in some of the situations in Europe, but we didn't prepare any formal presentation, and we really didn't know we were on the agenda till this morning. So if you'll excuse any foreign elements that slip in, we'll appreciate it.

I guess my role in this is to give you a little background on SSR (Secondary Surveillance Radar), which is what ATCRBS is called in Europe.

EU Region Responsibilities.

The European (EU) Region, is a very small region as far as people are concerned, but it equals 3/4's of the geographical surface of the USA.

In the regional headquarters, we have a staff of 21 specialists, and several field organizations, which provide flight inspection for military and NATO organizations in Europe. Our responsibilities cover the gamut from such things as certifying the Concord SST in its airworthiness program, if it's to be sold in the United States, to maintain surveillance over the air carriers that operate in Europe, the American air carriers. From an air traffic control viewpoint, we have 13 specialists assigned to an air traffic staff which conducts liasson with the European government with the Europe Control Organization, which Colonel Williams will touch on shortly, and represents the United States on a NATO Committee which has to do with air space coordination over Europe.

This committee which I will be talking further about is known as CEAC, Committee for European Airspace Coordination. Its the only committee in Europe which is dealing with the problems of coordination of air traffic control between the military and air space management.

Europe's Problem.

This is an intense problem in the European area because not only do you have a great mixture of countries - 15 within the NATO organization itself, but a great deal more when you expand beyond that, with their separate air traffic control systems which they are trying to work cooperatively, but in many cases you have a separate and independent military air traffic control system, operating alongside the civil one.

On top of this, there is an international organization of seven countries in Europe, identified as Eurocontrol, which controls the upper air space over the European continent. So you can see from this mixture that the liasson with the countries, and the primary effort to keep them informed about the United States ATCRBS is one of our major missions, as well as reporting to the United States what these countries are doing in this area.

Air Carrier Problem.

There is a problem in that air carriers are different in Europe. Those air carriers that go to the United States generally are equipped with transponders. Domestic carriers generally are not so equipped. The Caravels particularly, so that only 40 to 50 percent of the air carriers operating in Europe are transponder equipped.

Most of the time, general aviation is not the problem in Europe. There is not as much of it to begin with, but that which is there is relatively well equipped, operated by some of the big businesses.

Code Allocation Problem.

A problem which we have still not confronted is a commonly agreed code allocation system, which is still up in the air there. You can just imagine the problem involved in this - many parties, trying to get agreement on something. A common ordinary problem on how to word it sometimes may take several months to get agreement on the very wording that will go into an agreement of this type.

CEAC.

I'd like to talk about CEAC. This is a committee on NATO: One of the prime committees on it (Figure 5). It is a committee which monitors air traffic control activity, although it has no authority to effect changes in the various systems. Its primary job is coordinating the civil and military traffic procedures - particularly the numerous military flights. It is also the prime means of standardization between the melange of nations and systems.

Secondary radar in Europe or ATCRBS is progressing. We do have quite a bit of capability at this time. There are a number of terminal areas - Paris, London, Frankfort, - which are requiring use of transponders to operate in the terminal area itself. By 1974 the upper air space will probably have this requirement also.

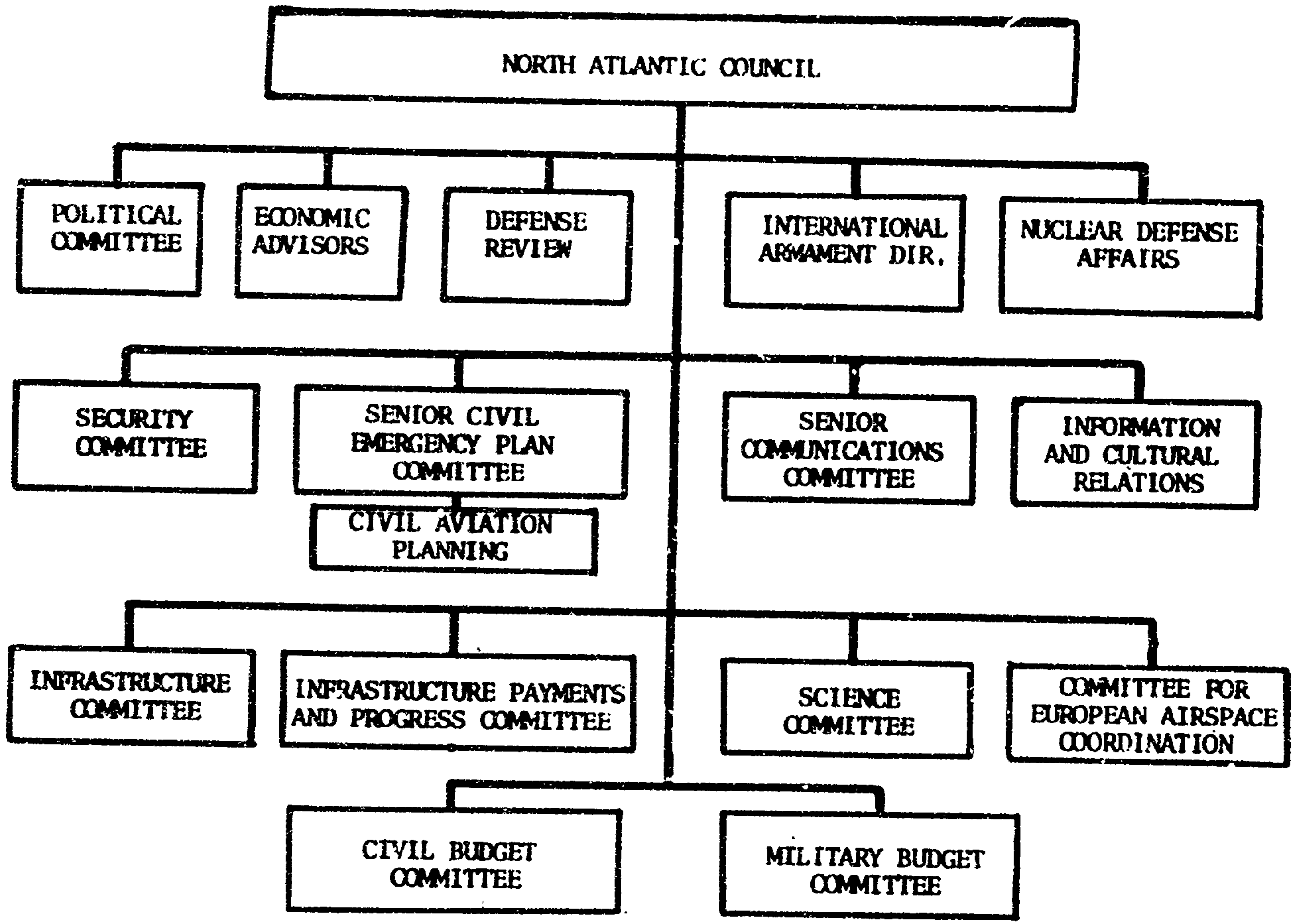


FIGURE 5. THE PLACE OF CEAC ON NATO

CEAC RECOMMENDATIONS TO NATO FOR EUROCONTROL

by Lt. Col. Norman E. Williams, USAFE (DOL-CEAC) (5)

The problems that we have in Europe, not only through the coordination of 15 nations, but sometimes through coordination with our own country's problems, are much like the problems being put here before this committee. We also have special problems being faced by the Europeans.

Those of you who have seen the European ICAO regional navigation plan have seen the map from which Figure 6 comes. The area of the circles and the width of the lines give you a 5-day average of the traffic in those areas.

This is a 1970 map. It is 12.5 percent out of date. You can see that the USAFE military bases are caught pretty much in a cobweb of circles.

Each of these bases has landing radar - either a GCA or the FN-47 and all have the IFFIS secondary radar.

Eurocontrol.

Figure 7 shows the area of control the Eurocontrol organization will have in 1974. Eurocontrol is a consortium of seven nations, six of which are NATO nations. As it is now, NATO can only suggest changes in radar policy - the nations complying only when the suggestion is in accordance with their own thinking. Eurocontrol would take over control of all the aircraft in the upper airspace. They are about two years behind in their plan to do this.

All of their control will be done using secondary radar - automatic tracking, and things of this kind.

Air Traffic.

Figure 8 shows the time in minutes which it takes an aircraft to fly through these particular FIR's. This is a 575-mile flight from Copenhagen to Paris. You can see that the SST will take a much shorter time to fly through. People in the field say, "We've almost got to turn our antennae faster or these guys will go by without ever hitting the antennae." If the antennae hit them only once or twice and we should lose an interrogation, we are hurting. So these nations are pressing very stronly for the resolution of an overinterrogation, or a missing beacon target return.

FIGURE 6. EUROPEAN ICAO REGIONAL NAVIGATION PLAN

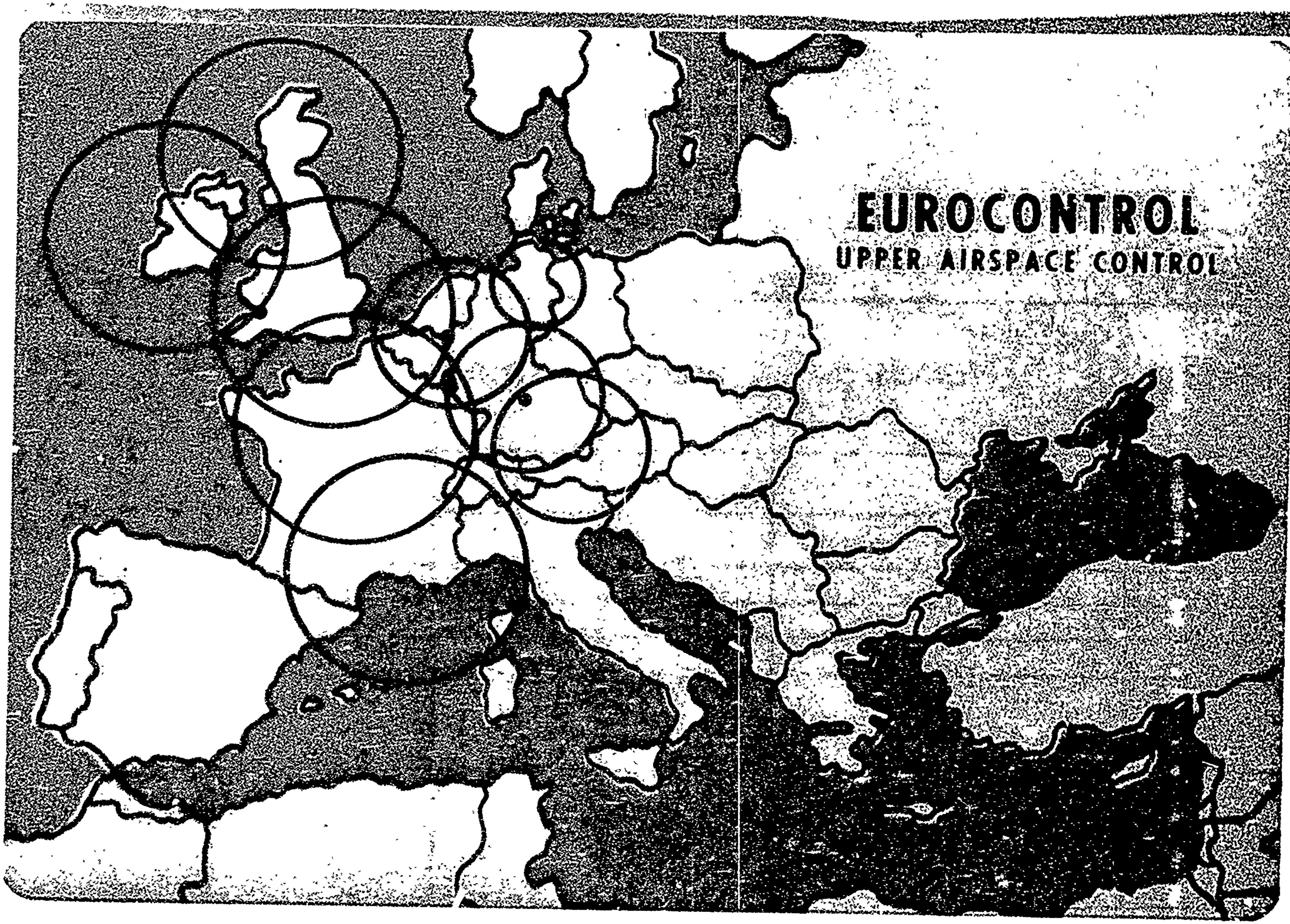


FIGURE 7. THE AREA OF CONTROL OF THE EUROCONTROL ORGANIZATION

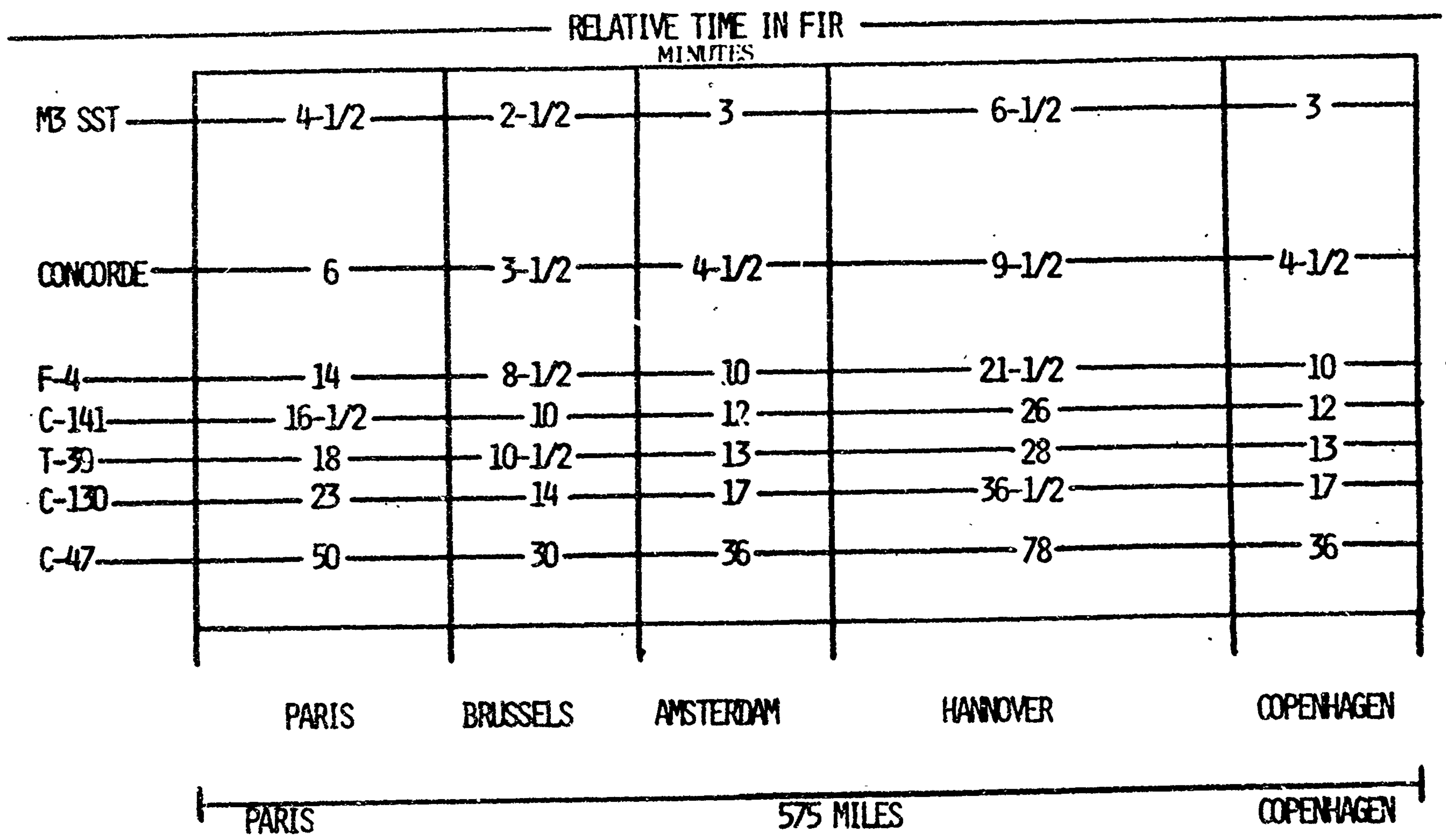


FIGURE 8. THE TIME IT TAKES TO FLY THESE FIR'S

You can see what would happen in the Brussels area with 3.5 minutes for the SST.

Coordination Problem.

In the United States you would not have this coordination problem with five nations speaking four different languages. When the FAA puts out an order, it is done; but we do not have that luxury in Europe. We have people saying, "O.K. fine, we'll go back and consult our administrators and we'll take it up six months later at the meeting."

Overinterrogation.

The area of overinterrogation that my group is studying is 80 miles west of Frankfurt, where we have suspected that there is an overinterrogation problem (Figure 9). The interrogators of Switzerland, Austria, Czechoslovakia, East Germany, Netherlands, Belgium, France, and Luxemburg, each having about a 200-mile range, can sweep this area. We have taken the EEC suggestion and done computer work on this problem on all of the parameters of secondary radar - such things as screening angles on the military radar, proper elevation, and antenna rotations. We have been on this a year now. It takes a little bit of time to do this. We also are having security problems with the United States in releasing this information.

List of CEAC Recommendations.

I shall give you a list of recommendations we have by this committee, and an idea of the success of these recommendations. The studies are both technical and operational, but mainly operational.

1. We have recommended the installation of 3-pulsed, side lobe suppressed interrogators, and 20 and 23 percent of the 15 nations have obtained these.

2. A reduction of power to the lowest limit operationally required. The AFCS have a power reduction kit that can be used for this in the CPN-4 and the MPN-14 type GCA units in Europe. It costs less than $30.00, and has been extremely successful. The power of the interrogator is controllable from 1500 to 0 watts. Not all GCA units need to pump out 200 miles - sometimes only 25 miles is all that is needed. Targets are being received just as well within the operational area using this power reduction technique.

Using this technique, the United Kingdom reported a 50% reduction in interrogations in their area. This $30 breadboard has improved the area considerably.

3. We recommended that the PRF be at the lowest operational amount.

4. We recommended that interrogators, that do not have side lobe suppression, be turned off completely when not used for actual control of aircraft. After an airplane is landed the GCA should be turned off until needed.

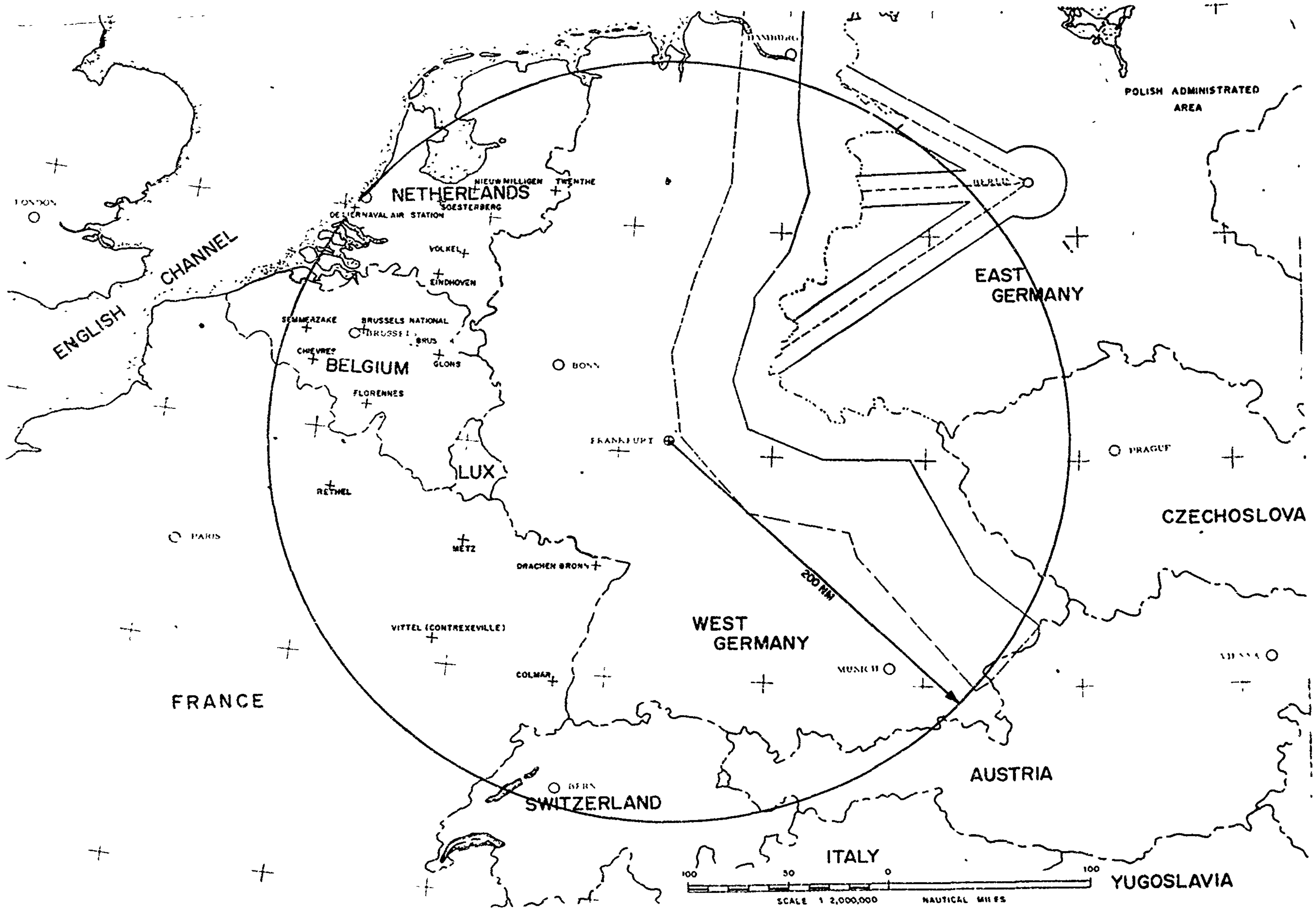


FIGURE 9. THE 200-MILE RANGE OF THE FRANKFORT RADAR

5. We recommended that the American fleet, when near the coast, shut down their interrogators, and reduce the number of interrogators in that area. The Italians started this request, and the British followed. Now all shipping is restricted in the use of their interrogators within 50 miles of any coastline, and in the FIR's of Athens, Rome, Milano, all the UK FIR's, and France, too. France, incidentally, is a very productive member of the CEAC committee.

The European nations have each passed a law which says that we have 4096 codes and Mode C readout by June of 1971. The military has until January 1973.

This about covers the situation in Europe. We have tried to get all your reports, and we have tried to send our reports to you. I hope they have been productive for you.

BROKEN TARGETS WORKSHOP

PROBLEMS OF BROKEN TARGETS AND WHAT TO DO ABOUT THEM

by Joseph E. Herrmann, OP-4 (6)

All Was Not Well.

As the beacon system came into widespread use during the mid-sixties, it wasn't long before FAA Headquarters started receiving reports that all was not well. Targets were reported breaking up, some were missing replies and fruit rates were high. The Central Region submitted a detailed report which SRDS used as the basis for correspondence with the Department of Defense in 1966. The DOD agreed that joint effort was needed to identify the causes and apply corrective measures. It was proposed that a group be formed to investigate the problem. The first FAA/DOD meeting was held in February 1967 where a Chairman was selected to lead the activities of the Beacon System Interference Problem Subgroup. Monthly meetings were held initially in order to get started and presently the meetings are held three times a year, to coincide with the FAA flight inspection schedules.

Points of Contact.

The subgroup identified a number of short term actions that could be started quickly with immediate results. The Frequency Management Division, RD-500, was identified as the national central office for PRF assignments. Mr. Gerald Markey is the central point of contact in matters concerning PRF usage.

All fixed interrogators within the continental U.S. have a PRF assignment which are listed in the files monitored by the Frequency Management Division. This listing is also made available to the Electromagnetic Capability Analysis Center (ECAC) at Annapolis, Maryland. ECAC is a DOD facility heavily involved in studies of radio and radar interference.

Points of contact with the major DOD Services and FAA were established for quick resolution of PRF conflicts.

Techniques for Investigating.

The Subgroup initiated a routine reporting technique to identify geographical areas where high interrogation rates were prevalent (see Figures 10 and 11). The FAA flight inspection activities include a Semi-Automated Flight Inspection (SAFI) function that covers the country on a grid basis. An indicator lamp was installed in each SAFI aircraft that would turn on whenever the on-board transponder received over 1000 interrogators per second on Mode 3/A. The time and position of the aircraft was recorded for each occurrence of the high interrogation light and SRDS plotted these positions on a national map. These locations were called "hot spots" and the Subgroup distributes the maps with the minutes of each meeting.

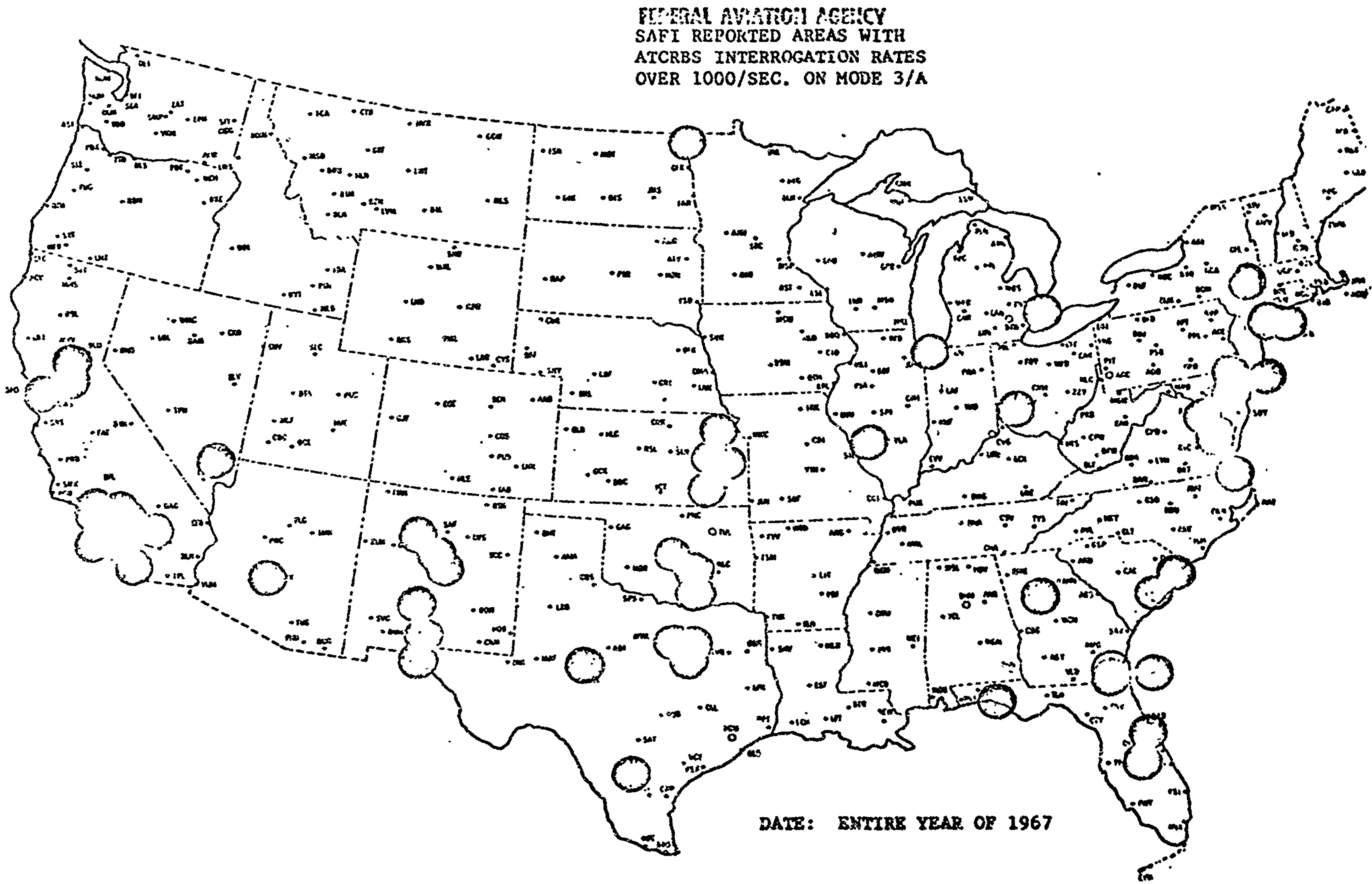


FIGURE 10. HIGH INTERROGATION AREAS 1967

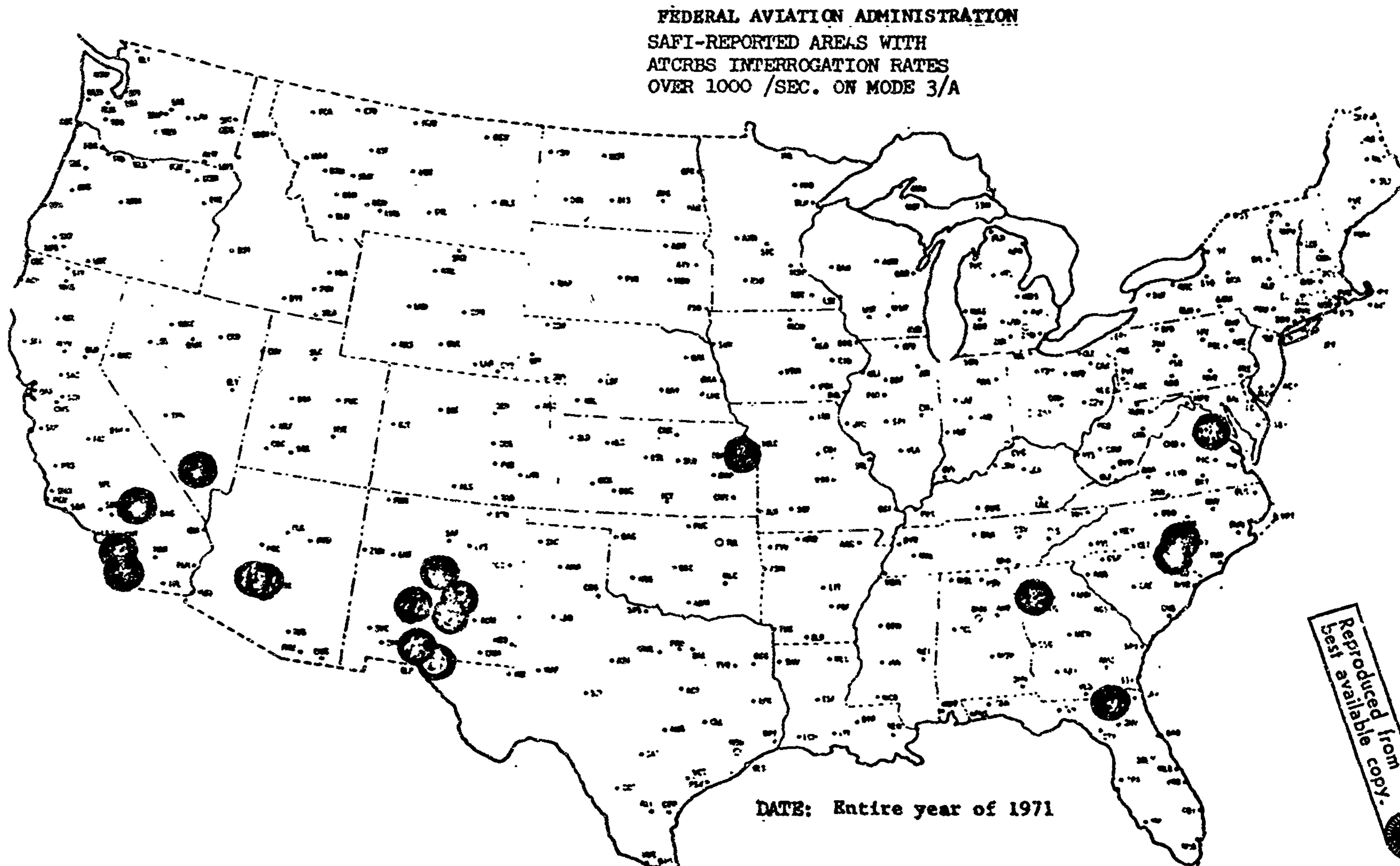


FIGURE 11. HIGH INTERROGATION AREAS 1971

A detailed investigation of one of the predominant hot spots was initiated by the Subgroup. The New York City area was selected and the Air Force provided a specially instrumented C-141 aircraft. The FAA recorded the system performance as the USAF aircraft followed a predetermined flight path. NAFEC and the ARTS sites participated as well as the Aerospace Defense Command sites. All data was analyzed by the AIL Division of Cutler-Hammer under an FAA contract and a report was published.

Controller Input.

An analysis of the ATCRBS from the controller's viewpoint was made through a nationwide survey. For a 30-day period in 1968, all controllers were asked to report deficiencies on a special form prepared for the test (Figure 12). Over 12,000 reports were received which were analyzed and documented in an SRDS report dated January 1970. The report was most valuable in spotlighting the major problems on a national basis and it helped expedite the procurement and installation of side lobe suppression at FAA interrogators.

Power Reduction.

The Subgroup initiated action within FAA to reduce ATCBI-3 interrogator power levels. An Agency Order was approved in 1967 which directed all FAA sites to reduce power to the minimum level needed. This action resulted in improved performance at most sites by reducing side lobe breakthroughs and fruit. The impact of power reduction was also evident by a reduction of hot spots detected by the SAFI aircraft.

Power reduction modifications were developed by NAFEC for the UPX-1, UPX-6, and UPX-14 interrogators which were under the control of FAA. The DOD, however, has resisted power reduction and virtually all military interrogators still operate at full power.

Side Lobe Suppression.

The FAA has implemented SLS at 90 percent of the interrogator sites. Only the older interrogators used at RAPCON and RATCC sites are not equipped. The ADC sites are operating with SLS at all but a few locations. This action was taken after the Subgroup encouraged the Air Force to conduct a series of tests which proved the effectiveness of SLS. The remaining militaary ATC sites will be getting SLS as part of the AIMS implementation program to be completed in 1975.

It is obvious that all transponders must have SLS capability in order to take advantage of the ground program. The FAA aircraft carriers are 100 percent equipped with SLS. General aviation transponders are virtually 100 percent equipped with SLS, however, a large percentage are not properly maintained and the SLS performance is not fully effective. The DOD is approximately 30 percent equipped with SLS and their rate of changeover is tied to the AIMS program.

30-DAY CONTROLLER SURVEY - 1968

PROBLEM	MAGNITUDE	SOLUTION
FALSE TARGETS (GHOSTS)	30%	TECH
WEAK TARGETS (FADES & LOST)	29%	TECH/MGMT
RING AROUND (SIDE LOBES)	23%	TECH/MGMT
BROKEN TARGETS (SPLITS)	18%	MGMT

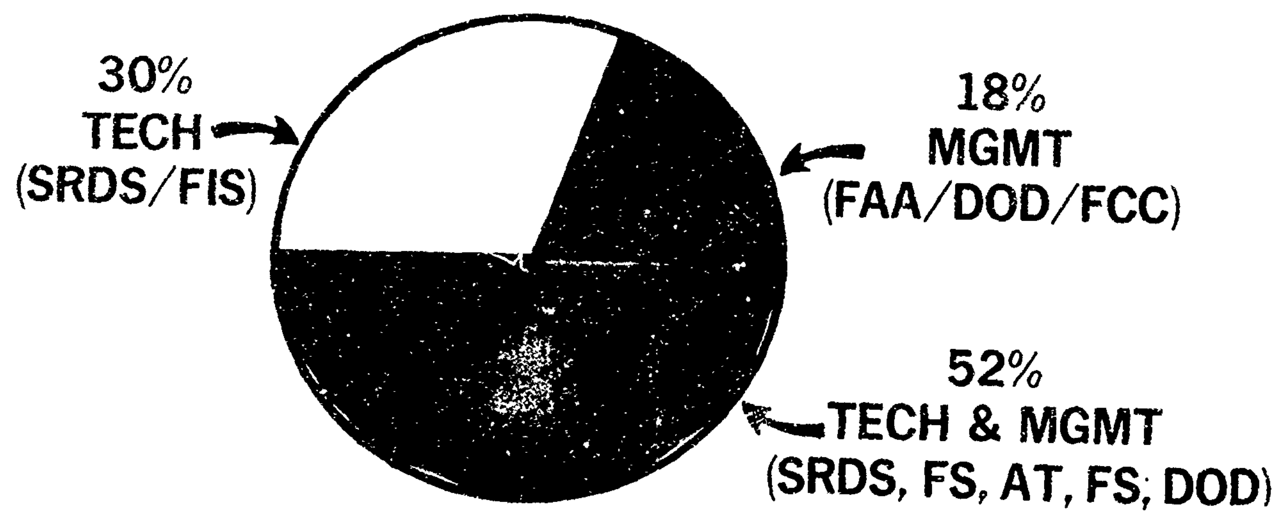


FIGURE 12. 30-DAY CONTROLLER SURVEY - 1968

Overinterrogation.

The unnecessary operation of interrogators is currently being studied. FAA issued an Order to operate only those interrogators needed to support air traffic control. This Order had little practical impact since all sites except NAFEC and the Academy are needed full time. However, the FAA action made it clear to other users of the system that we were doing all that we could to minimize interference.

The DOD notified their Commands in 1967 to minimize interrogator operation. Industry was also advised to minimize interrogator operation through letters sent out by government contracting officers. They were advised of the interference problem and to coordinate their operation with local FAA frequency management offices.

Beacon System Interference Problem Subgroup Follow-Up.

In December 1971, the subgroup initiated a limited follow-up controller survey to evaluate the present performance of ATCRBS as compared to the 1967 results. With widespread implementation of SLS by the FAA, the system problems should show some marked changes. The results of the limited 14-day survey should shed more light on the system performance and guide corrective action on the problems that remain. The analysis of the controller reports is being done by the Transportation Systems Center (TSC). A final report will be completed by July 1972.

The subgroup also established long range goals for maintaining acceptable system performance. An accurate tool for measuring system performance and predicting future performance is needed. Towards this goal, an ATCRBS simulator is being developed at TSC. Many system tests have been conducted and the results are being used to validate the computer parameters used in the simulator. A second system model is being refined at ECAC which will have somewhat different applications in the analysis of ATCRBS performance. Together, the TSC simulator and the ECAC model will be effective tools to analyze system problems and predict future performance under the increased traffic densities.

Long Range Controls.

Long range controls on the use of the system are essential to avoid saturation and complete breakdown. A centralized management of the system is needed to control the deployment and use of ATCRBS by FAA, DOD, and industry.

Maintenance of transponders varies over wide extremes. The air carriers have an excellent program in maintenance, while, at the other extreme, some general aviation transponders receive virtually no attention until they become inoperative. In this regard, the FAA is preparing rule-making action to require that all civil transponders meet minimum standards and be tested on a yearly basis.

A system monitoring program is underway withi . SRDS to develop airborne monitors. These equipments will be used in place of the present SAFI "hot spots" detectors. The new monitors will measure and record the essential parameters of interrogators to assure proper operation meeting the requirements of the ATCRBS National Standard. Out of tolerance interrogators will be located and identified for corrective action. Unlisted interrogators can be detected and located for appropriate follow-on action.

Rule-Making.

The subgroup activities have been very productive in areas of interference reduction and system tests. However, the subgroup has not been able to make noticeable progress in rule-making and implementation of improved equipment. A recommendation was submitted through channels to FAA Administrator level for the establishment of a full time management team. It was agreed to place the team under the Associate Administrator for Operations and within the Program Management Staff, OP-4. The DOD has provided a full-time representative, Lt. Col. Alan Good, USAF, to work with me on this team.

False Target Solution.

The controller survey conducted in 1968 showed that false targets represented 30 percent of the system problems (Figure 12). The solution to this problem is essentially the implementation of an improved beacon antenna with sharp underside pattern cutoff. SRDS has a development program started to meet this requirement.

Lost Target Solution.

The problem of weak, fading and lost targets was reported in 29 percent of the controller survey forms. The solution to this problem is a combination of technical and management actions. Weak targets can be caused by antenna deficiencies, a technical problem, or by deficient transponders which do not meet minimum standards, a management problem. If the FAA continues to allow nonstandard transponders to periodically readjust critical parameters, then we will continue to have weak and fading targets. It requires a management action to establish minimum performance and maintenance requirements through rule-making action.

Ring Around Solution.

To minimize ring around and side lobe breakthrough problems requires a combination of technical and management actions. These problems were repeated in 23 percent of the forms. Interrogator antenna deficiencies and poor siting, a technical problem, or nonstandard transponders and/or poorly maintained transponders, a management problem, can cause the ring around condition.

Broken Target Solution.

Broken targets and split targets, which is the subject of my discussion, were reported in 18 percent of the forms. A broken target is one where some transponder replies are not received within the main beamwidth of the interrogator antenna. The major cause of broken targets is due to high transponder interrogation rates or high transponder suppression rates. It indicates that many interrogators are being used in the area and the corrective action is to minimize their operation. These problems basically require management action. It involves control of the deployment and usage of interrogators.

Dead Time.

The reason why a transponder does not reply to each interrogation is predominantly caused by dead time or suppression time. If the interrogator pulse pair arrives at the transponder slightly after some other interrogator's pulse pair, it will not elicit a reply since the transponder has already initiated reply action to the other interrogator. The transponder can only answer one interrogation at a time. It will not respond to another interrogation for a dead time period which varies from 25 to 150 s depending upon the design of the transponder. The same conditon applies when a suppression pulse pair received from the side lobe pattern of the interrogator antenna of some other site has temporarily put the transponder in a suppression state. This suppression action lasts from 25 to 45 s.

Automatic Overload Control.

If the transponder is being interrogated by a very high rate of over 1200 per second, it reduces receiver sensitivity so that weaker interrogation signals are rejected. This condition is called automatic overload control (AOC) and will reject your interrogation if your interrogation signal is weak such as can occur at maximum range or within antenna lobing area.

Antenna Placement.

Many military aircraft use two transponder antennas located on top and bottom of the fuselage. Only one antenna is connected at any given instant through a single pole double throw switch which cycles at a rate of 38 times a second. This rate is fast enough to change antennas several times as the en route interrogator main beam scans across the aircraft. If only the bottom antenna has line-of-sight to the ground site, then the transponder replies will be missing when the top antenna is connected. The result on the PPI display will show a broken target with approximately half of the replies missing.

Overinterrogation.

The term "overinterrogation" has been used for may years but there was not general agreement on the meaning. The subgroup adopted a definition of the term and recommended that it be used to avoid confusion. This definition reads "Overinterrogation is defined as the denial of transponder replies to valid interrogators due to the action of the reply rate limit circuit in the transponder."

Let's look at the interrogator environment in the United States. There are airborne interrogators in many Air Force and Navy aircraft. Over 300 interrogators are used aboard Navy ships and a small number aboard Coast Guard ships. Military services operate ground mobile and field facilities. Industry tests interrogators at their facilities as part of development and production programs for government agencies. Some universities operate interrogators as part of their research programs and the FAA operates some 200 interrogators. Added all together, the totals run into several thousand units. On top of these, hundreds of ramp test sets are used to check out transponders. The older type ramp test set used by the military were actually high power interrogators running hundreds of watts. The newer AIMS test sets are low power units which should cause little interference. Airlines and general aviation also use ramp test sets, but they are all very low power units. But even low power ramp test sets can cause severe interference if they operate at or close to a PRF in use by a nearby interrogator. When this happens, a synchronous fruit problem is created that cannot be eliminated with defruiters. Mr. Markey of the Frequency Management Division has this under control through assignment of low PRF rates to ramp test sets.

Many transponders include a self-test feature which is actually a built-in minature interrogator. By activating a spring loaded switch on the transponder control panel, the transponder is interrogated and a go-no go lamp indictes transmitter operation. Many of these self-testers operate at high rates and can cause broken targets and interference for brief periods. Until the FAA establishes transponder minimum standards, there is no means of limiting the PRF of these self-testers.

Hot spots have been plotted since 1967 and the improvement over the years can be seen on the five maps for the years 1967 through 1971.

Broken Targets Minimization.

There are a number of steps that field people can take to minimize broken targets (Table 8). It is important to know your IFF neighbors. Find out who operates interrogators in your area through the local Frequency Management Office. Establish contact with them and open up lines of communication to discuss interference problems. Become acquainted with their equipment capability, are they using SLS and what power level and PRF is used. Inquire about their antenna scan rate and whether sector scan or search-lightning is done. Investigate the usage of high power ramp test sets and PRF's used.

TABLE 8. WHAT CAN BE DONE TO MINIMIZE BROKEN TARGETS

1. Up-To-Date Listing Of All Interrogators Within Line Of Sight To Aircraft.

2. Establish Points Of Contact With All Non-FAA Interrogator Sites.

3. Can Interrogator Power Be Reduced At Offending Site? Is SLS Being Used?

4. Is Offending Site Searchlighting Or Sector Scanning?

5. Is A High Power Ramp Test Set In Use?

6. Identify Aircraft Which Have Consistent Broken Targets (Military--Air Carrier--General Aviation) And Follow-Up With Users.

7. Defruiter OK? Mode Interlace OK?

8. Unusual Problem?
   - TACAN
   - UHF TV

9. Airborne Interrogator?
   - Happens For Short Periods
   - Military Training Activity

10. Mark XII - Mode 4 Used In Area?

11. Measure Interrogation Rate If Necessary To Locate Unknown Source (SAFI-NAFEC).

12. RFI Van Useful
    - Locate 1030 MHZ Sites
    - Listen To 1090 MHZ Reply And Note Reply Rate (Indirect Measure Of Interrogation Rate)

If some aircraft in your area seem to have target breakup more than others, follow up on these and determine what type of antenna is used. It could well be due to a top/bottom antenna switch configuration. Some military aircraft are set to reply to Mode 1 and/or 2 as well as Mode 3/A. A high interrogator level on Modes 1 or 2 could be the reason for poor performance on Mode 3/A.

Your own defruiter may be causing loss of replies and result in broken targets. A careful adjustment of the defruiter may solve your problem.

Be sure that the mode interlace circuitry in the interrogator is working properly. Any instability may cause loss of target.

Don't overlook unusual problems that may crop up in you area. A TACAN station operating near 1030 MHz or even a UHF TV station second harmonic can upset the operation of some transponders.

An occasional flight through your area by a military aircraft equipped with an airborne interrogator can cause brief periods of broken targets or fruit. These may be hard to pinpoint, but they must always be considered in analyzing system problems.

The military will be implementing Mark XII interrogators at many sites. These are operated infrequently but when they interrogate on Mode 4 they will suppress transponders rather than elicit replies. They can cause some target breakup, but our tests indicate little noticeable impact. It would be well to know where these interrogators are used in your area.

Measuring Interrogation Rate.

If you experience a broken target problem in your area that cannot be solved, it would be well to measure the transponder interrogation rate. NAFEC has the capability to measure airborne interrogation and they are available to assist by request through channels. The RFI van located in many regions can be used in most cases. If the RFI van can be parked on high ground, it can search the area with a directional antenn tuned to 1030 MHz. Another simple technique is to use a portable 1030 MHz receiver such as the receiving portion of a transponder and a hand held directional antenna. The unit I have on display today was made from a transponder and operates from a 12-volt battery. I built an audio oscillator into the unit so that unknown PRF rates can be identified.

Another approach is to use a 1090 MHz receiver and listen to the transponder replies. They will indirectly permit you to listen to all line-of-sight interrogators that are interrogating the aircraft transponders.

If you use a directional antenna and point it at one aircraft, you can interpret the ground interrogator environment that is reaching that aircraft. The transponder replies that you hear are simply a relay of interrogator environment in your area. The receiver I have in my hand came from a transponder and was retuned to 1090 MHz. This receiver was used to investigate

interference in the Washington area and the following recording which you are listening to came from an aircraft near Washington. The extremely high PRF which you hear is well above the 450 maximum rate and is certainly not coming from an FAA interrogator. Unusual interrogation such as this can cause considerable system interference.

With tools such as these, many sources of system problems can be identified in the field without NAFEC assistance. An RFI van or hand-held portable receiver on 1030 or 1090 MHz can be extremely useful in tracking down local sources of interference.

Now, finally, if any attendees of this seminar would like to get the minutes of the Beacon Systems Interference Subgroup meetings, please give me your name and mailing address.

THE REAL WORLD OF A DIGITAL BEACON TRACKING SYSTEM

by August S. Hall, Jr. NS-10.2 (7)

The title of my talk tonight is: "The Real World of a Digital Beacon Tracking System." I feel especially prepared for this topic because at the Jacksonville Center, we have been operational with the NAS Stage A Beacon Tracking System in the high altitude for over 7 months. The tracking data are being provided from the ATC radar beacon system and all of the problems discussed here the past few days have been encountered.

These problems have been a source of concern for us, since to introduce or sell a new product, whether it be an automobile or automation, it should have two inherent qualities. One, it should be as good as or better than the old, and two, it should work for you and make your job easier, like power steering, power brakes, etc. At Jacksonville, we have not been able to fully realize these qualities.

To fully appreciate the end effect, we must see what happens to the display the controller uses for traffic control. In addition, we must also consider what happens in the data processing function between the point of acquisition and display.

I mention these items primarily to point out that the information displayed through the broadband mode could be considered usable, but not usable in the digital processing and display mode.

To illustrate I have prepared a series of figures to show what can and does happen with just the problem of split or broken targets.

Broadband Display.

First let's see what the display looks like with broken beacon targets on the present day broadband system. In Figure 13, we show two aircraft being given radar separation on parallel tracks which would normally be expected to proceed on diverging course over Charleston, South Carolina.

As the targets approach the radar site from the northeast after a handoff from the Washington Center, we are receiving strong returns. Now as they approach the area where the beacon breaks up, the targets are still easily identified for tracking purposes. However, you will note the faded or nonpainted areas of the beacon return. The general outline of the target slash is still there. This is no real serious problem because the controller can mentally and visually determine the aircraft location. This is not a desirable display, but still considered useable.

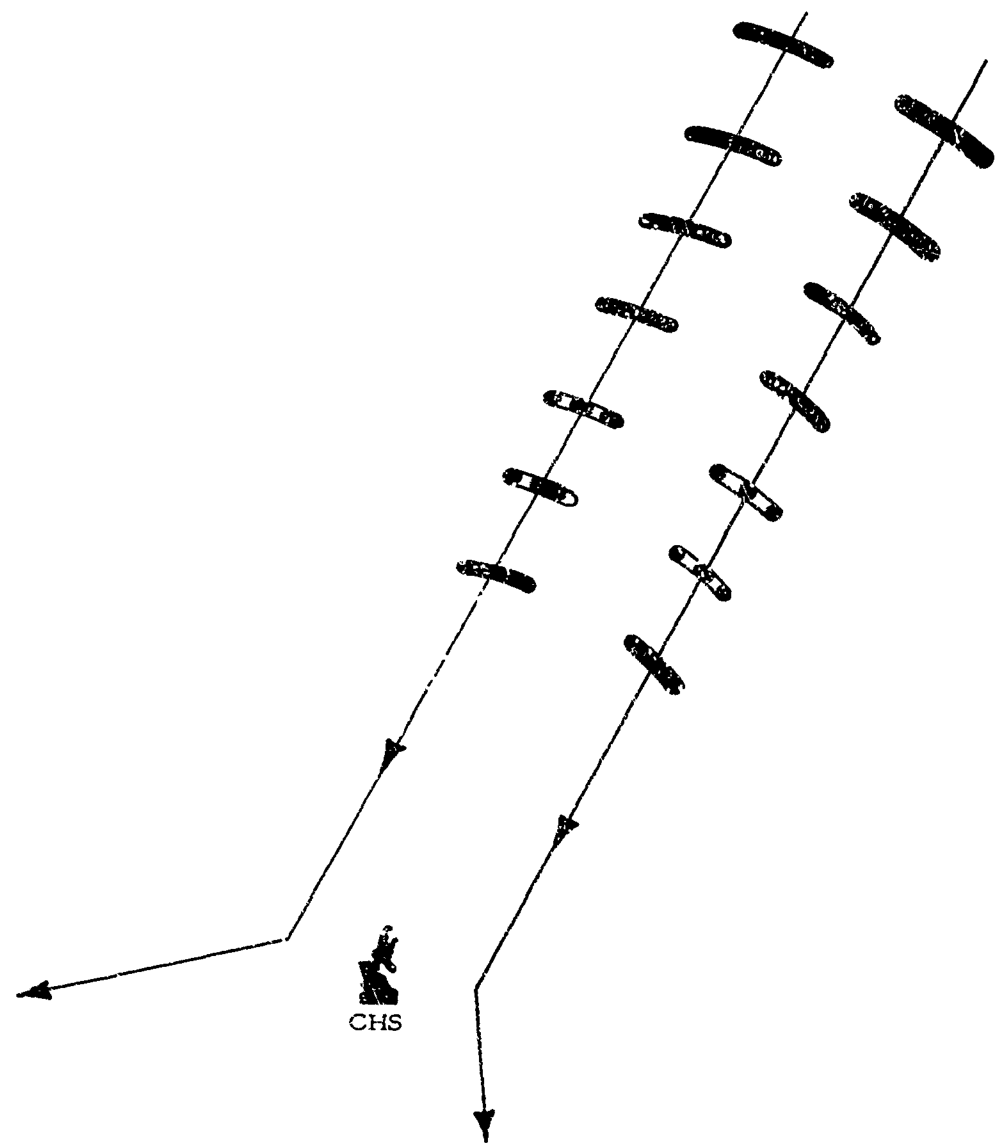


FIGURE 13. BROAD BAND BROKEN TARGETS

Narrowband Display.

Now let's look at what happens in the narrowband or digital system with processed video (Figure 14). In this case, it is the track of a single target on a discrete beacon code. The data block has been purposely left off of most of the locations only for the purpose of showing what can and does happen. In this example, as the aircraft is approaching from the same direction as before, the target presentation is clear and much more precise than in the broadband system. There is really no problem with fading targets, since if the common digitizer declares a target, weak or strong, the display symbology remains the same size and intensity. The data block information normally presented at the controller's option is type-of-track, leader, aircraft identification, and assigned altitude. In this case, the diamond indicates this is a flight plan aided track, and the aircraft is equipped with discrete code and altitude reporting equipment.

The letter "C" indicating transmitted altitude corresponds to assigned altitude. The next position is where the target breaks up and appears to be five individual targets. However, in this case the second target from the right is the one which contained the correct beacon code, therefore, the data tag acquires on it. Altitude information was not contained in this message, therefore, the system presents the data as though the aircraft was not equipped with altitude reporting equipment. In the next position shown, the target is broken up and the system is displaying four separate targets, however, none of the targets contain the proper code data, therefore, the data tag has gone into the coast mode. This occurs when, for three successive scans, no usable target was detected. The solid rectangle symbology, the word coast (CST) and an attention bar appears to alert the controller. Again, note the absence of the "C" with respect to altitude information. In the next position, a single target was processed with all correct information and the data block automatically reacquired.

Now let's look at two tracks being given radar vectors as in Figure 15, and see what can happen. Everything is fine in the area of good beacon data returns. The presentation has small precise targets, regardless of range, and the data blocks are well displaced to the right and left. In fact, we could be running these two aircraft closer together than with the broadband targets. In this case, we have Eastern Flight 124 at flight level 330 on a discrete beacon code and transmitting altitude information as indicated by the letter "C." The other aircraft is National Flight 263, assigned flight level 330, however, he is on code 2100 (non-discrete) and does not have altitude reporting equipment. The "A" beside his altitude shows we have entered a progress report on him at flight level 330. If a progress report had not been entered, the letter "N" would appear instead of the "A."

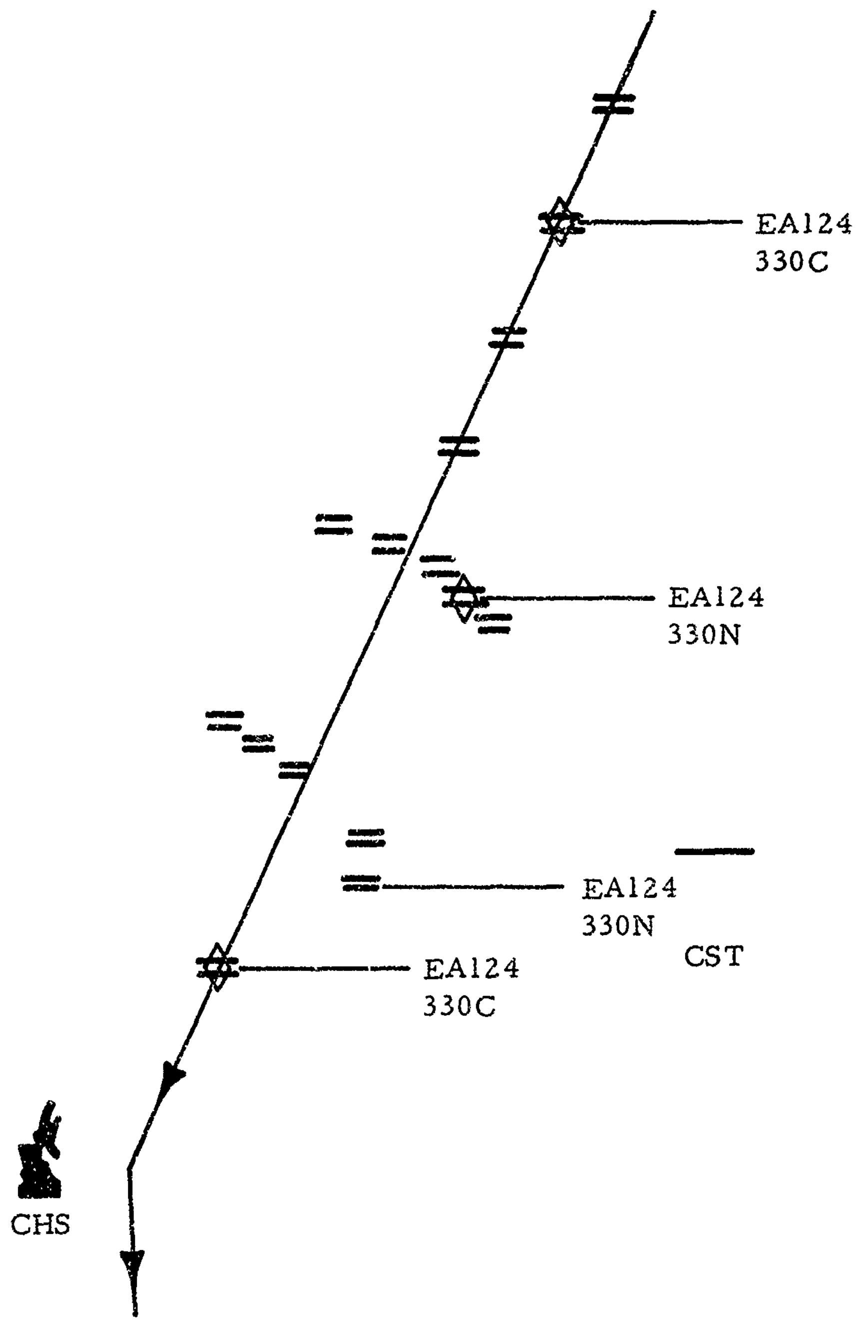


FIGURE 14. NARROW BAND BROKEN "SPLIT" TARGETS

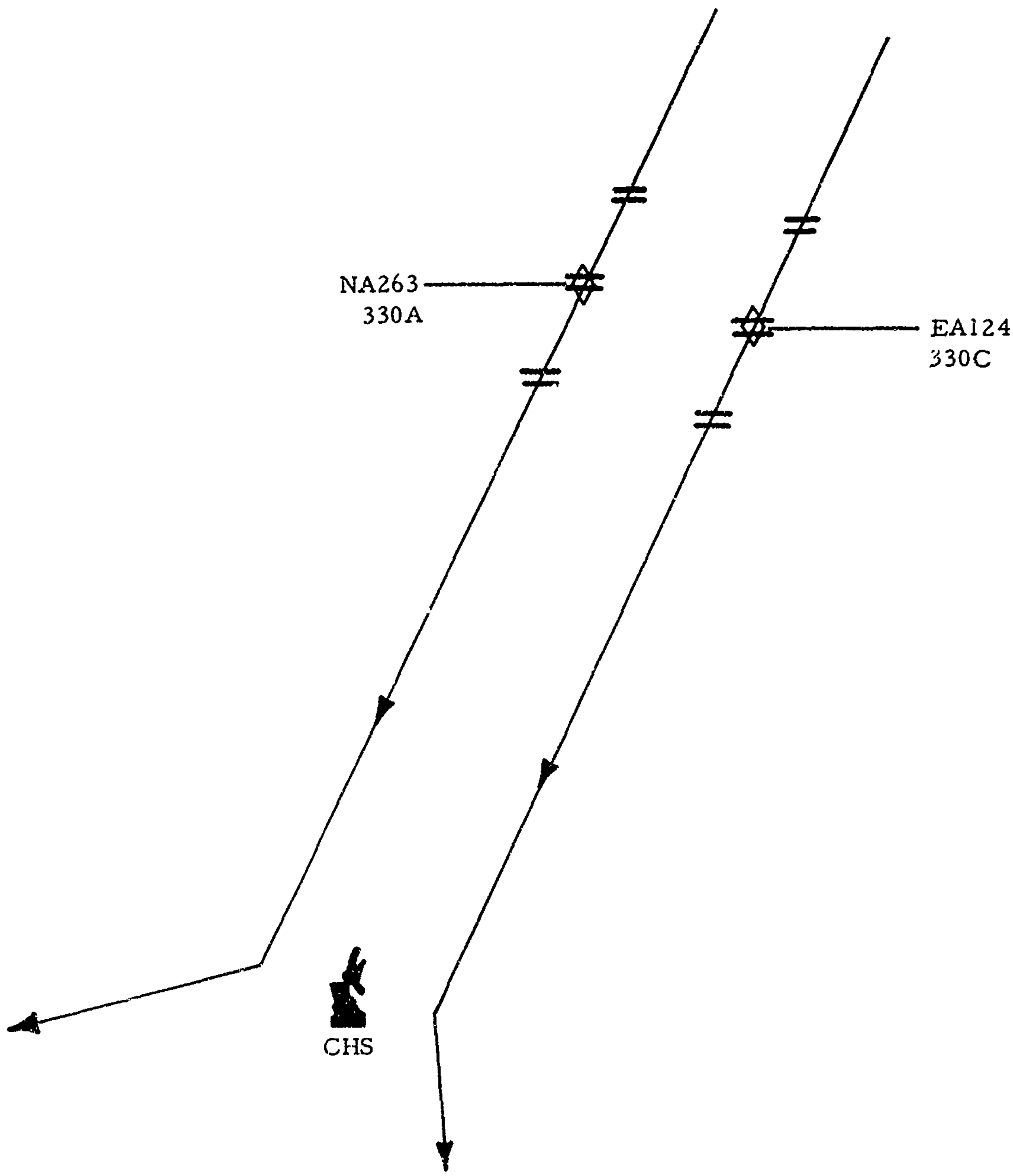


FIGURE 15. NARROW BAND PARALLEL TRACKS

Split Returns.

Figure 16 shows the two aircraft now in the area of split targets. Now see what can happen to the display, although the aircraft are still on parallel tracks while in the area of splits. The situation I have depicted is not uncommon. Let's examine what has occurred. The visually displayed position of the two flights have moved and I repeat the visual display has moved. Had the controller's attention been diverted to another area of the scope for two or three sweeps, would he really know if the aircraft had possibly made turns or were they still separated.

In the case of National 263, the target to the right of his course had Code 2100 in its message, and it was within the 4-mile search area that the system was looking during the next scan. The target to the left of centerline could also have contained Code 2100 in its message and was within the 4 mile area, but the system selected the right hand target. In the case of Eastern 124, the far left target was the one in which the message contained the correct discrete code and was within the 6 mile search area.

Now, imagine if you can, this same situation if there were possibly six or more tracks in the same vicinity. Confusing, to say the least. Also, if two or more of the aircraft were on Code 2100 (non-discrete) those tracks could swap back and forth.

System Recovery.

Now let's see how the system recovers from this situation once we begin to receive valid, non-split targets for these aircraft. For the sake of clarity, I will show what happens to each aircraft in separate figures. First let's take Eastern 124, which is on a discrete beacon code (Figure 17). The system will search within a 6 mile area to locate a valid target. If a valid target was received, automatic acquisition would occur. But in this case, the program looks within a 6 mile search area of the last track position and did not pick up a target. However, the real valid target may have appeared at its actual position along the route of flight. The program then projected and caused to be displayed the track symbology, the diamond, along the projected course from the last track position which was erroneous due to the splits. In this example, for three successive scans, the real target continued to be just out of the search area from the last track displayed position. After three scans and no valid target is received within the search area the track will go into coast as indicated by the diamond changing to a solid rectangle. After going into coast, the system will search within 75 miles of projected flight plan position and will reacquire if a valid target is received.

In Figure 18 slide we show National Flight 263 on Code 2100 (non-discrete). The system looks within a 4-mile search area of his last position for a valid target. If one is detected, the track would continue on the new

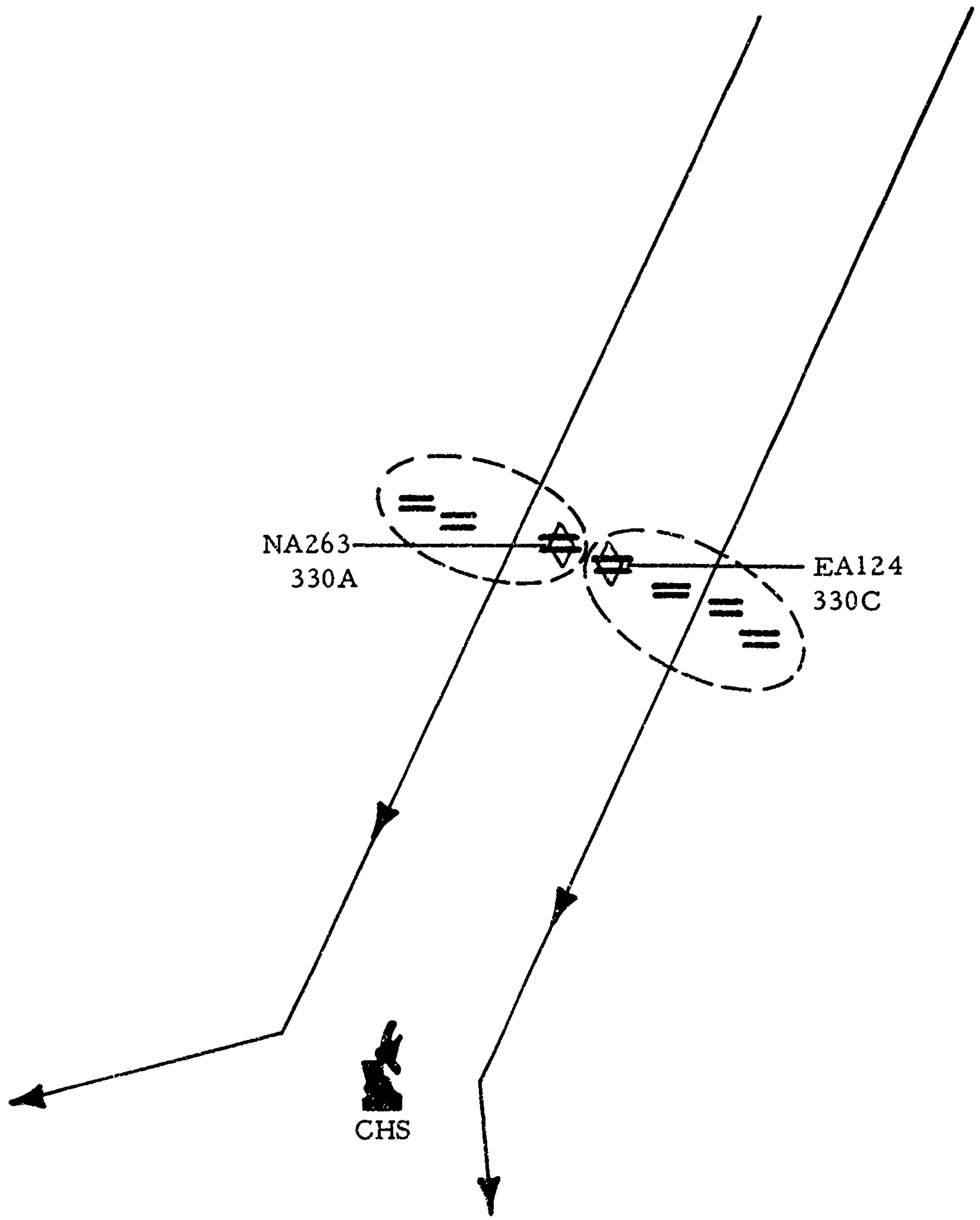


FIGURE 16. NARROW BAND BROKEN "SPLIT" TARGET

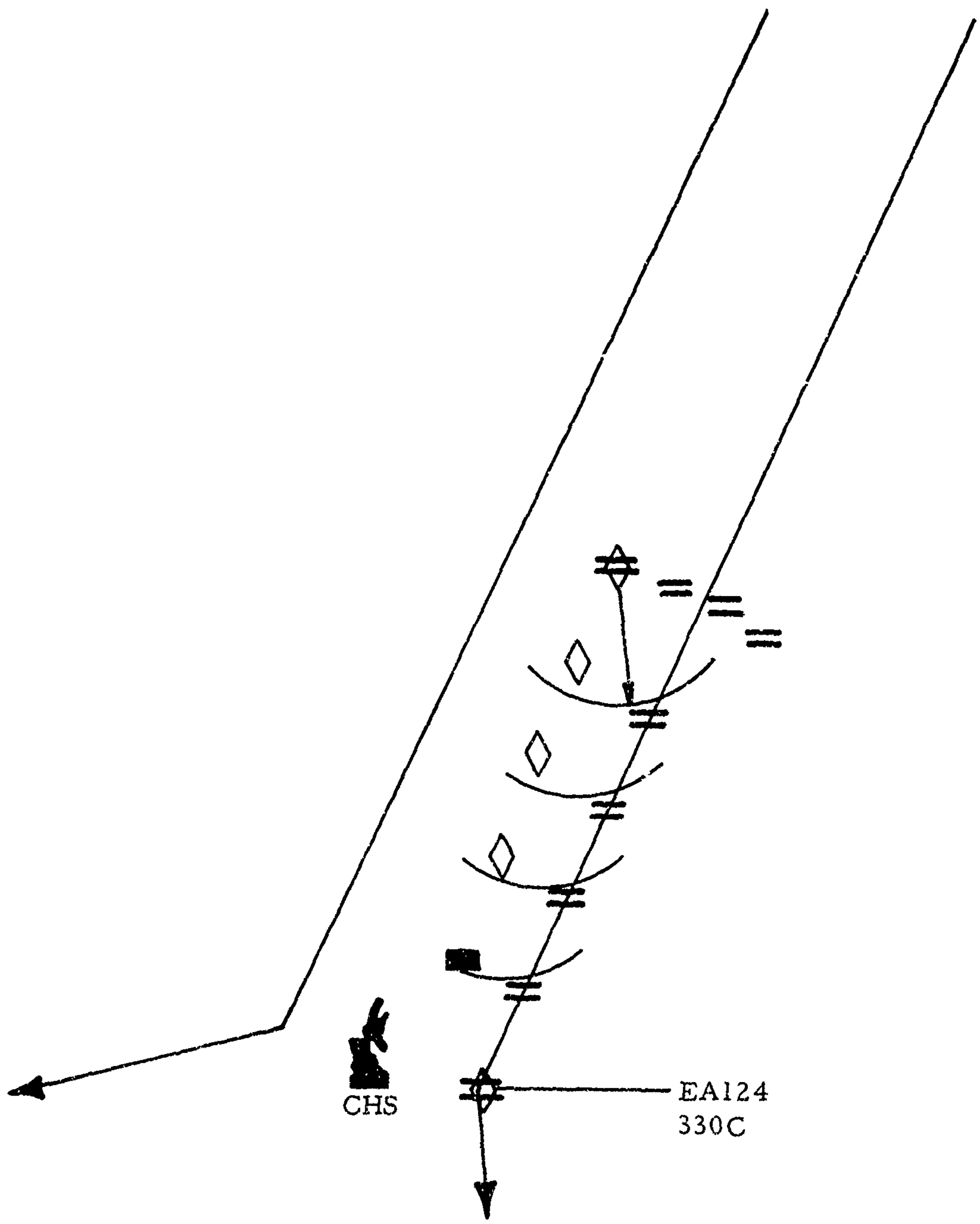


FIGURE 17. RECOVERING THE EA 124 TARGET

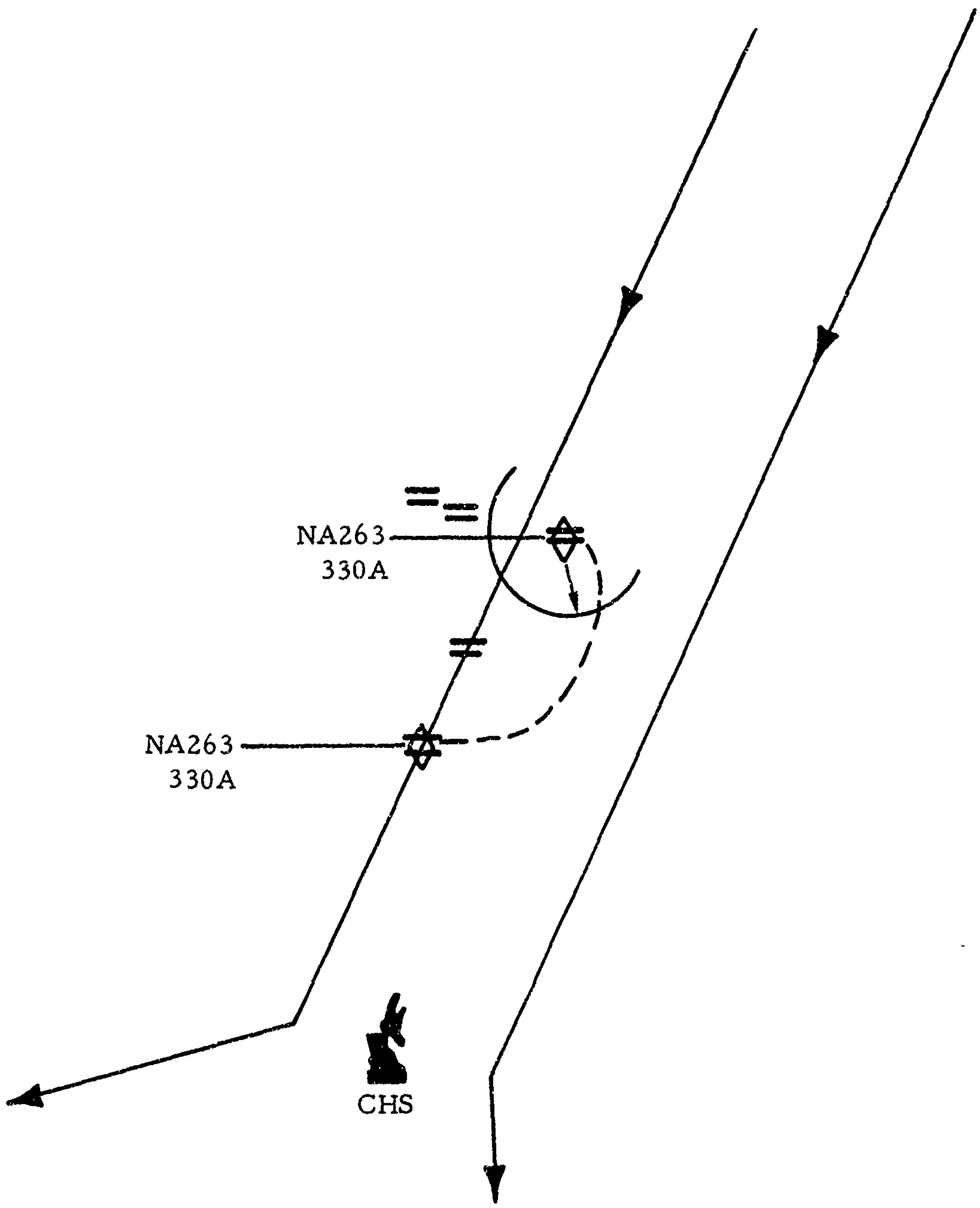


FIGURE 18. RECOVERING THE NA 263 TARGET

target. In this example, none is present, therefore, after three scans the track will go into coast. To reacquire the track, controller action is required in which the slew dot is used to reposition the track to the new position of the target. Automatic acquisition of non-discrete targets does not occur.

The examples I have shown and discussed are all related to the broken or split target problem. In my opinion, this problem is one of greatest concern to the controller, since radar separation cannot be used in these areas, handoffs cannot be made or accepted, and acquisition of new tracks is impossible, and these are some of the more significant benefits to be realized from the automated system. In summary, the data which is finally displayed to the controller for his use can only be as good as the information fed into the system. This also holds true for missing targets, false targets, etc.

Automation Problems.

Now, what are some of the side effects caused from these problems:

1. Controllers will be reluctant to accept the system if they cannot have confidence in the displayed position of aircraft being tracked. Confidence in the system and reliability are "musts" if we are going to complete the transition from present manual radar tracking to an automated tracking system.

2. There is a definite loss of the automated system capabilities, such as those already pointed out, i.e., radar separation, automatic acquisition and tracking, handoffs, etc.

3. We don't like to talk about, "system errors." One of the goals of automation is to increase safety through more accurate processing and display of aircraft position. This certainly requires accurate and precise position data.

Multiple Radar Processing.

I have shown you the worst side of the Beacon Tracking System due to problems within the ATC Radar Beacon System. Now let me point out a significant "plus" factor or design feature of the NAS Stage A which minimizes these problems. This is multiple radar processing and display.

Figure 19 shows overlapping radar coverage from one or more radars. For the purpose of processing and displaying radar data, the geographical area is divided into 25-mile squares called radar sort boxes. Within each sort box we identify the preferred radar site and a supplementary site. If radar data of an aircraft is received from the preferred site, this is

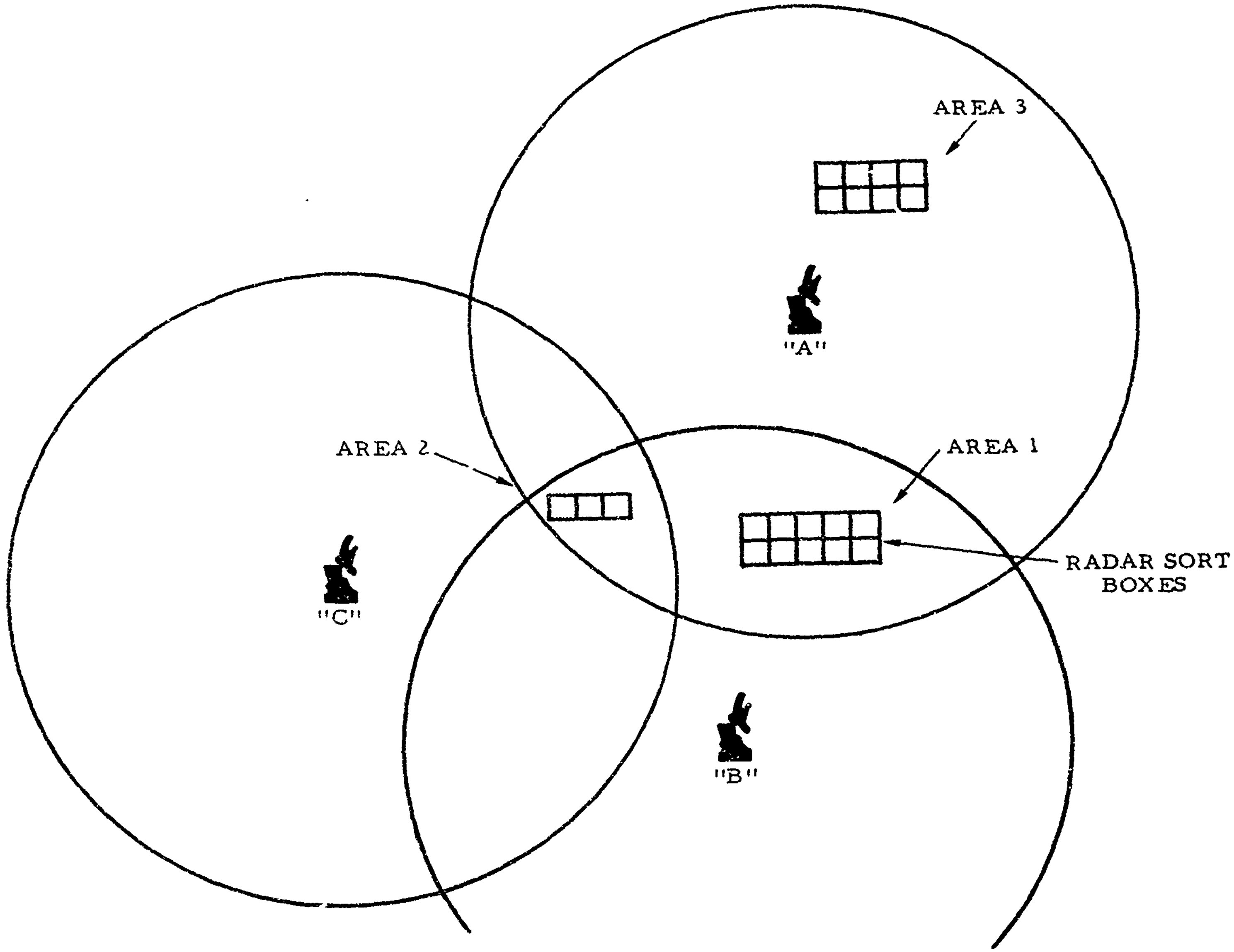


FIGURE 19. OVERLAPPING RADAR COVERAGE

processed and displayed. If no returns are received from the preferred site, then we process and display the data from the supplementary site. In the area shown by the radar sort boxes, we have a split target or missing target problem from Site "B" but not from Site "A." Then Site "A" would be designated as the preferred site and would be used for processing. This would eliminate the display of broken targets from Site B." However, if we lose coverage from Site "A," the problem returns because we then use Site "B" as backup. In Area 2, we have three choices of radar sites and a better chance of eliminating the problem. There will always be cases like area 3 where there is no redundant coverage, thus, the problem must be corrected at the source.

I am sure that these problems can be corrected. It does, however, require engineering know-how, time, and money. We have the engineering expertise and with the proper priority, the money. However, time is still our most critical element. Firing-line personnel live in the "now" world, and not what can be done in 6 months or a year. Their reaction is "fix it now." I am hopeful that the results of this seminar will highlight the expedience of early corrective measures before other beacon tracking systems are implemented.

WHAT TO DO WHEN ATC AUTOMATION SPOILS ATC VIDEO

(From The Discussion On Broken Targets)

QUESTION: Commissioning of facilities to automated operation, ARTS III, NAS Stage A, and so forth, requires the interrogator interlace modes 3A and C, sometimes also mode 2. Operation of the interrogator and these interlac interlace modes, to satisfy the testing of the automation equipment, causes target breakup to the operator observing targets in the manual mode. What steps are being taken to minimize the impact of this on ATC operations, and to advise the field that this condition must be tolerated during the transition period between manual and automated operation?

ANSWERS: Larry Craig: The first three facilities that had this problem for Mode C and Mode 3A interlace were the New York common IFR room, Atlanta, and Knoxville. These were all automation facilities, and all three of them were interrogating Mode C.

Being new on the scene the first time I was aware of the problem was when the Chicago O'Hare Tower turned on their mode C interrogation prior to the commissioning of ARTS III, and they were pretty up in arms about it. So in researching it I thought the best thing to do was to go back to Knoxville Atlanta, and New York, and find out what I could find out.

The first thing that I found out from New York was that most people didn't even realize that they had this interlace; that the beacon target was serrated in appearance this way, and to many of them it had been that way for a long time, and was acceptable. As a side issue I found out that the Navy purposely operates their beacon slashes in this form. So we asked the Great Lakes Region, Chicago to just live with it awhile, and see what the outcome was, and after this first 2 or 3 week period where the controllers said it was pretty bad, they seemed to forget about the problem, at least minimize it.

Recently when I visited the facility the controllers said; "Yeh, its there, but it doesn't really give us much of a problem."

As to desemination into the field of the fact that this condition will be there, I guess I have to charge myself with being guilty, because we haven't put anything out into the field forwarning them of this problem, and it sounds like we should.

George Mahnken: On the technical side of the house, depending on the mode of operation that the controllers use, there is or is not something that can be done.

In the decoders you have the mode gates that are generated and they do inhibit video during the wrong mode. So if you're decoding common system, for example, you can modify those mode gates and let through everything being decoded, at least bracket-wise.

If you're running a strictly select-mode or select-code type of operation, such as common to a high altitude structure, you have to live with it, and that's it. There is nothing you can do. But the mode gates can be removed in the decoding equipment so that you can at least let brackets through, and those aircraft that do reply to mode C, and for mode 2, will be displayed at least as a slash.

George Spingler: We were asked to check into an interlace problem that existed at Knoxville a number of years ago, and this might not have anything to do with this exact question, but we set up some equipment which actually counted everyone of their PRF's. So that whenever they generated a certain mode, if it was correct, it wouldn't count up in this counter. But as soon as an incorrect mode was generated it would be counted.

This equipment is available if you should have any type of a question in the field as to whether your interlace ratio is correct, and how many incorrect modes are being generated over a period of time.

NAFEC could supply this equipment any time you required it.

BROKEN TARGET WORKSHOP SUMMARY

by Joseph E. Herrmann, OP-4 (6)

After the workshop on broken targets, listening to the questions and answers, the following conclusions were reached by the moderator.

1. High interrogation rates due to numerous interrogators in specific geographical areas are a major cause of broken targets.

2. Considerable differences in definition of beacon deficiencies exist, and it is difficult to communicate between controllers and technicians.

3. Many military and industrial interrogators operate in geographical areas capable of causing broken targets to air traffic control sites, and their existance is not generally known to FAA personnel.

4. There are inadequate controls on the operation of interrogators.

5. An effective control of PRF assignment appears underway through the FAA Frequency Management Division of SRDS.

I also have several recommendations.

1. FAA field personnel should establish complete lists of all interrogator sites and their areas of concern.

2. Direct communication should be established between FAA site personnel, and all other interrogator site personnel, in their area.

3. All regions should have an RFI Van for interference investigations.

4. Local FAA site technicians should make maximum use of RFI Vans, and other portable receiver equipment to investigate and monitor the interrogator operation causing high interrogation rates.

5. Sources of interference should be identified and reported to Frequency Management officers as quickly as possible.

6. A glossary of beacon deficiencies should be prepared and used by technicians and controllers alike in discussing and reporting problems.

7. The FAA must reach early agreement with the Department of Defense on the operation of ground shipboard and airborne interrogators in order to control the interrogation back in the continental United States.

FALSE EMERGENCY ALARMS WORKSHOP

THE PROBLEM OF FALSE EMERGENCY ALARMS UP TO 1965

by Anthony D. Bradley, NA-120 (8)

There have been several attempts to correct the false alarm problem. Actually, there are two technical means to do this; one is to modify the existing equipment, and the other is to replace the coding network that deals with the emergency decode circuitry with a black box or a new box. Both of these approaches have been attempted at NAFEC through SRDS programs.

I think also Larry has mentioned that this problem has existed for some time in the field. He mentioned one of the fixes that was used to correct the audio alarm was to cut the wires. One of the other fixes was to put a pencil through the speaker, but to disable the audio alarm is really not correcting anything, as you realize.

I might mention that these efforts date back before 1965 when reports were issued on modification of ATCBI-2 and ATCBI-3, which cover this problem. A lot of things have come into place since that time - economics, programs, other programs, ARTS, TPX-42, etc., which have, and will correct emergency decoding circuitry to the point where we do not have false alarms, or, when we do, they are very seldom. So, we are at a point now where we probably thought we were in 1965, and there would be a very real tendency to modify the existing equipment. It would be far better to replace it with the new equipments.

I can't really speak for post-1965 at NAFEC with regard to various fixes. I will however, cover one major effort, that is, the modifications to BI-2 and BI-3 systems. This effort was conducted by Mr. Jerry Waldman who has since left NAFEC and has joined the military. I had the good fortune to work with him on this effort in a minor way, and I would like to report on it for him. It is covered in a final report dated May 1965, Project Number 242-005-02V, which in itself, dates it.

Modifications.

Several modifications were made to the BI-2, BI-3 decoders. These included a comparison counter network, a scan grader network, a garble inhibit network, testing this on the various mode interlace and defruiting conditions.

Now, the criteria used during these tests were primarily directed towards how well the modifications performed with respect to decoding true emergency replies. Most of the effort was directed towards getting a true emergency reply when one is actually being transmitted. With each of these fixes, all the modifications made improvements.

I think that if you have experience in emergency alarm, a true emergency alarm, even with the 12-12 decoders, there is no mistaking one. It is there, and it is there all the time, and it is almost continuous. However, the other aspect of rejecting false alarms was of primary concern, and, in this area the results I think have to be interpreted with respect to what kind of performance you want.

Now, a controller who has a false alarm every hour will soon reject any alarm that occurs; however, I can't say how often a false alarm should occur, or what tolerable limits a controller has for accepting false alarms. So, with that in mind, the final data really is subject to interpretation.

Fix 1: Comparison Counter.

One of the fixes involved is a comparison counter. This comparison counter took the reply - a single flash reply - and counted the number of times, over a period of interrogations, an emergency alarm occurred. Various settings were used - 2, 3, 4 times. Now, as you may well imagine, with the 12 - 12 decoders, a single emergency alarm - 1 single reply, code 7700, or interpreted as code 7700 - will produce an emergency alarm. With a counting effect you can eliminate this single reply. If you set it at 2, the probabilities of receiving two of these during a certain runlength is very small. Settings of 2 to 3 to 4, - reduce the number of false alarms within a 35-hour period from 23 to 5, which is a sizeable reduction.

Fix 2: Scan-Integration.

Now, there is the scan-integration effect; that is, each scan of the antenna in an emergency reply has to repeat itself the next scan. You hit a scan - an emergency reply shows up - you don't display it. The next time around - if it is there - you display it and you alarm. This had a drastic effect on emergency false alarms - this reduced it from 23 to almost 1 during an 8 - hour period.

Fix 3: Garbled Circuits.

The other modification - the garble circuits, which are an improvement on the 12 - 12 decoder, each one of these fixes, incidentally, was used singly and in series during the test series - but the garble inhibit decreased the false alarms from 23 to about 4, so each one of these fixes that was evaluated in 1965 had a substantial effect in reducing the number of false alarms generated by 12 - 12 decoders.

The programs that were to follow, certainly had an impact on whether these modifications were implemented or not.

The next effort that came along after these modifications, was the other approach, using a separate box to do this function, which had some of these fixes in it, and your Chairman, Mr. Scavullo, recently conducted an evaluation of a military alarm decoder box AN/UPA-51. I think that his report will be

will be out shortly, but in that report Joe says that it had a substantial effect on reducing false alarms, but apparently the scan-integration technique looks like the most promising; however, there are drawbacks to that one, too.

We have two radar systems, primarily, terminal and en route. In the terminal area a four-second scan rate is not too bad, but in the en route the area would have to wait for scan-integration some 10 to 12 seconds before getting an emergency decode.

NO EFFORT FORESEEN TO FIX FALSE EMERGENCY ALARMS

by Ralph Bishop, SM-110 (9)

I would like to go back into a lot of this history, maybe, if I can take just a few minutes. The fixes that Tony has been referring to, of course, was the R&D effort. The things that were done in this program were put into the FAA program budgets for several years after the R&D effort, and, of course, in competition with other money, it never did survive, and it was again put into the '72 program and again did not survive. Putting money into the decoders that have a limited life, at least at this point, just doesn't compare with other priorities we just have to do, considering other equipment that is needed in the Air Traffic Control System. I don't believe there is going to be any effort to support it. I don't remember the cost of this mod but it was rather expensive so I don't believe there will be any further agency effort now. I am just speaking personally here. It may be put in, but it has never survived yet, and we don't expect it to survive as each year goes by and automation comes closer.

No Money.

On the maintenance side of the house, also, we have received over the past seven or eight years many suggestions from the field on how to fix these decoders. We have evaluated them, and usually find that they will reduce the false alarms but they also, in some instances, will eliminate true 7700 emergencies, and so, of course, we can't run that risk. There was a letter signed out by SM-1 - it has been two or three years ago - which recommended that the AFD (Airways Facilities Divisions in the Region) not extend further manhours in pursuing fixes for this decoder. Now this was only a recommendation - it is not firm. There is a fix available, but we can't afford it on the basis of the life of the decoders, and there is no money for mods in my program on the maintenance side of the house, so I don't believe that there will be very much effort put on these now.

AN/UPA-51.

Speaking about the UPA-51 evaluation, this started more from Joe Herrmann's side of the house, and he is trying to get the military to reduce power, and the military is sort of objecting on the basis that if they reduce power they will not be interrogating out at 200 miles and therefore, not seeing some of the military emergencies. They have sort of looked to an agency and military agreement which says that FAA will monitor military emergencies. Well, our 1212's do not monitor "4-Train" emergencies, so it was suggested that we look at the UPA-51 to do this job; and if we can monitor the 4-Train then maybe we can get the military to reduce power as we would accomplish part of their mission. The UPA-51 was sent to NAFEC and evaluated, and, of course, we asked them also while they were evaluating

this to determine if it would improve the 7700 decoding by reducing the false alarms that we were receiving; but now I don't believe there is any intent of using the UPA-51 - though it did look favorable from what NAFEC has said - for decoding 7700's. The Air Traffic people have asked us to look into the possibility of modifying it and using it for decoding 7600. We have a program to look at this at one of the Centers, we hope in the near future. I would like to say there is no plan, to my knowledge, of using UPA-51 for 7700's.

MANUFACTURERS AND SHIPS MAKE FALSE EMERGENCY REPLIES

By John Kemper, WE-406 (10)

I was rather surprised that no mention is made of two sources of emergency codes that have been plaguing the Western Region, and I know, in the Rocky Mountain Region, that used to be a part of ours. I guess you could call them intentional/accidental false alarms, if you will.

Contract 7700.

We got a large series of alarms lasting anywhere up to 15 minutes several times a day, we finally nailed it down to several manufactures in the area which had transponders sending 7700. They showed us the military contract that required it be done. We said "can't this be done in a screened room?" They said that would cost them too much money. So it got rather involved.

What I'm saying is that there are intential and also accidental false alarms that can be created by manufactures, even after we have been assured by military representatives in the FAA Office, or Regional Office, and we've had wonderful cooperation with them. What happens is that people change, and we found another one just a short time ago in December. He was alarming 5 times an hour as they were testing transponders they were making. It was in the contract,; it somehow got put back in again. So keep these in mind that some of these might be valid.

Transponders in the Drink.

Another one which is very critical to us on the Pacific Coast, and should be also on the Atlantic Coast, I don't know why but a number of Naval vessels use 7700 for some test function, the nature of which I have been unable to ascertain. They use it as long as 2 or 3 hours at a time.

A few years back when we were running down the manufacturers, it was hard work and sweat to go around and find the manufacturers and the unit. Nowadays, with common digitizers its a snap; push a button and the RAPI reads out the azimuth, down to an eighth of a mile, the PRF, the code, the whole works, and its real easy, except when you find the unit in a boat out in the drink, six miles out. We can look at it, we can see it there, and we've brought it to the attention of the Navy people in the area.

Its been surprising that they, for various reasons have been unable to communicate directly with the ships involved. We have had them as late as last Friday - the last thing as I left the office the thing was still going. I didn't get called Saturday so I guess the thing finally turned off.

It had gone for 5 hours, and it was 8.25 miles off of Point Vincent, LA. and every sweep, every time, very typical, The Port Authority and umpteen other people had been notified - and this thing was still going.

<u>HELP</u>.

This happens all too frequently, unfortunately, all over our coast. We are getting some real good help from Commander Latta of the first fleet, and he's taken some real interest in it, and he's really rattling the cages.

We found in trying to find some of these, when we would give them the code that's being transponded over the phone - don't misunderstand us - but one answer we got was "Somebody in the Navy has got the code identification book but I don't know who." Out of the clear sky we called up and said we had a problem. So we caught them unawares. But there are a number of specific intentionally generated 7700 codes that come out, and the regional frequency management people, if you notify them when this type of thing occurs, I think they'll be a big help to you.

THE BEACON FALSE EMERGENCY PROBLEM AT SALT LAKE, AND THE DESIRABILITY OF ELIMINATING CODE 2300

by John H. Condon, RM-433 (11)

Statement of Problem

The Salt Lake City Center is experiencing a large number of false emergency replies to the extent that a true emergency could be overlooked or ignored, particularly on the Rock Springs, Cedar City, and Battle Mountain radar systems.

The problem of false emergency beacons occurred as a major problem approximately 18 months ago when positive control airspace altitudes were changed. At this time the controllers attempted to live with the problem.

Controller complaints generally show a lack of confidence in the system. Controllers continuously comment that if we are to have an aircraft false emergency beacon alert system we should make it work. The controllers felt that they could not appropriately live with the system that worked only partially. They consider this a major irritation problem and have issued at least one UCR on the problem. It is also noted that the false emergency problem appears to exist on all radars except the Lovell and Ashton system, and we understand that it occasionally exists on them. As a result of the complaints, an investigation of the problem was initiated.

Video Photographs

Part of the beacon investigation consisted of taking photographs of the video that initiated the false emergencies. This was accomplished by monitoring the video at the output of DL6101 (TP40) in the common-B decoder with an oscilloscope and camera. A tektronix 545A scope was set up in the single sweep external trigger mode with the external trigger supplied by the emergency pulse at TP 20 in the common-A decoder. A Fairchild camera was attached to the scope and the shutter opened. Receival of an emergency pulse train generated the emergency pulse which triggered the scope. The delayed emergency pulse train was in this way photographed at TP-40. The resulting photographs are part of this report and are filed at the Salt Lake City Center Sector Office.

The photographs were taken during the hours of 10:00 a.m. to 12:00 noon on 25 August 1971 and 9 September 1971. All emergency pulse trains that occurred during the two periods were photographed, except approximately 5 percent, which occurred while the scope and camera were being prepared for the next picture. A total of 64 photographs were taken during the two periods. Three of the emergencies appear to be caused by noise, the remainder appear to be caused by the interleaving of two reply-code trains.

The next step in the investigation was an attempt to establish the range characteristics of the Rock Springs (RKS) beacon system. This RDS system apparently has more false emergencies than the other systems in the Salt Lake City Center control area.

Range Limitations

The three main factors controlling maximum range are horizon limitation, site power - transponder receiver sensitivity, and transponder power - site receiver sensitivity.

a. Horizon Limitation

Considering the site is located at 10,000 feet and the horizon at 7,000 feet, the line-of-site range was calculated as follows:

A/C at 40,000 feet

$$D = 1.23 \; (\; hx + \; ha \;)$$

$$D = 1.23 \; (\; \overline{10{,}000-7{,}000} \; + \; \overline{40{,}000-7{,}000})$$

D = 292 Nautical Miles (nmi)

A/C at 30,000 feet

$$D = 1.23 \; (\; \overline{10{,}000-7{,}000} \; + \; \overline{30{,}000-7{,}000})$$

D = 25[illegible] nmi

A/C at 35,000 feet

$$D = 1.23 \; (\; \overline{10{,}000-7{,}000} \; + \; \overline{35{,}000-7{,}000})$$

D = 273 nmi

Since most A/C routed over the RKS site are at an altitude of between 30,000 and 40,000 feet, the average line-of-sight range is approximately 270 nmi.

b. Site to Transponder Limitation (Up Link)

The power reduction tests indicate that 200 miles of range is achieved with site transmit power set at 500 watts and the receiver minimum trigger level (MTL) set at -69 dBm, increasing the power to 630 watts (1 dB) and setting the MTL at -74 dBm, increasing the range to 400 nmi. The -74 dBm nominal value was obtained from a commercial airlines maintenance depot.

c. Transponder to Site Limitation (Down Link)

Based on the up link range of 400 nmi, a minimum detectable signal value of -88 dBm, and a transponder power output of 500 watts, the down link calculated range is 1,780 nmi. The 500-watt nominal value was obtained from a commercial airlines maintenance depot.

d. Range Limit Summary

1. Average line-of-sight range is 270 nmi.

2.	Site Power 630 W	X-Ponder Sens -74 dB	Nominal RA 400
3.	X-Ponder Power 500 W	Site Sens -88 dB	Nominal RA 1780

Possibilities for Interleaving Replies

a. Overlapping Area, Same Pulse Repetition Frequency (PRF)

With the range limits determined in the previous paragraphs, it is evident that sites with the same PRF have overlapping areas. The Rock Springs and Battle Mountain sites are located approximately 390 nmi apart. If the overlapping area contains many aircraft, the probability of interleaving replies may be significant. If the PRF's do not differ by more than approximately .02 percent, the defruiter may not eliminate the non-synchronous reply, and Code 7700 could result.

b. Equal Distance A/C

Aircraft located equal distance or varying in distance by some increment represented by 2.9 s of radar time and both positioned in the antenna beam at the same time can generate interleaving replies. If the replies combine to form Code 7700 a false emergency can result. With two aircraft approaching or departing a site at slightly different speeds and a crossover distance existing, the probability of interleaving replies is high. Heavy traffic on airlanes between Salt Lake City and Denver provide many opportunities for aircraft pairs to be equal distance from the SECRA site and in the beam at the same time.

c. Reflections

Reflections of the beacon replies could be another source of false emergencies. Excessive reply power, mountainous terrain and the large number of false emergencies that occur in the 20 to 40 mile range are factors supporting this possibility.

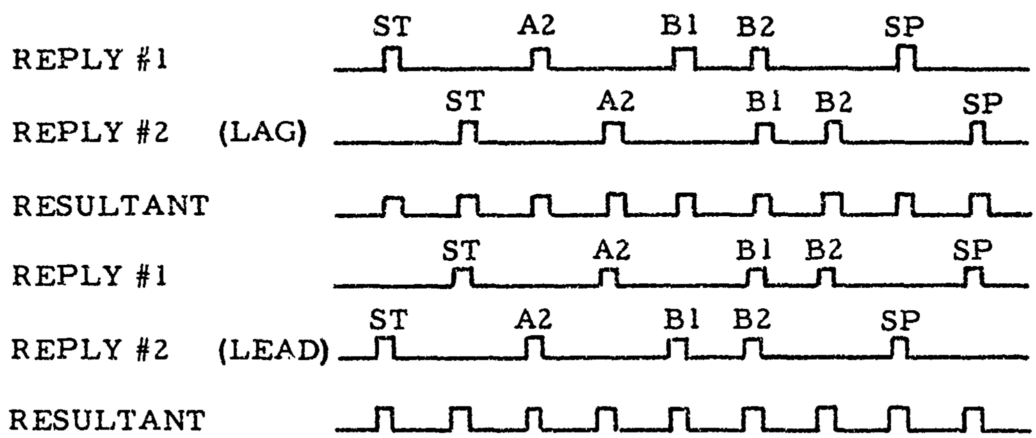
d. Non-Synchronous and Second Time Around Targets

Second time around replies and replies triggered by adjacent sites could cause false emergencies. The defruiters and interlacing should eliminate this possibility. Adjacent sites have different PRF and this permits elimination by the defruiter. The improved side lobe suppression (ISLS) modification prevents interlace operation of the Battle Mountain System.

Code Analysis

A normal mode 3/A emergency pulse train consists of eight pulses spaced 2.9 s apart as indicated below:

When an emergency pulse train is received, a double bloomer is generated for visual display. Also a red light is pulsed on several times. As indicated by the photographs, a false emergency can be generated by a burst of noise or by the interleaving of two reply codes. The two most troublesome codes being used in the RKS area are 2300 and 2100. Two Code 2300 replies can combine in two ways to form the emergency code as indicated below:



Similarly, 2300 and 2100 combine to form an emergency pulse train if 2100 leads 2300 by one pulse period. It can be shown that if the pulse trains contain two or less A and B pulses, there is no possible way for two interleaving code trains to form an emergency code. Twenty-two acceptable codes are as follows: 0000, 0100, 0200, 0300, 0400, 0500, 0600, 1000, 1100, 1200, 1400, 2000, 2100, 2200, 2400, 3000, 4000, 4100, 4200, 4400, 5000, and 6000.

Of the many code assignments specified in Handbook 7110.9B, only three fall within this class of codes that readily produce false emergency decodes. These are Codes 7600, radio failure; 2300, FL 350 to 600 en route; and 2500, FL 350 to 600 en route stratification. Code 7600, due to its infrequent use, has not presented an operational problem at the Salt Lake City Center. Code 2500 is not used in this area and is therefore not a problem. Code 2300, however, is in general use and accounts for a majority of false emergency decodes.

Possible Solutions

a. Code Change

The investigation up to this point indicates that a code change is the most practical solution. The possibility of interleaving would be eliminated regardless of how the two replies originate.

Most of the codes used in the Salt Lake City area are on the acceptable list indicated in Code Analysis. Our recommended solution is to use only codes from the acceptable list. The major apparent drawback to this solution is that the number of possible codes is reduced from 64 to 22. This fix has the advantage of no wiring or circuit changes.

b. Emergency Code Change

Another possibility would be to change the emergency code from "7700" to "0000." This fix has the advantage of not reducing the number of available codes. The disadvantage is that circuit changes would be required in the transponder and in the indicator site decoder.

c. Transmission of C or D Pulse

Another fix would be to have the transponder transmit a C or D pulse with all code trains except the emergency code train. This fix would involve activation of the corresponding C or D kill pulse circuit in the indicator site decoder. Complexity of the transponder change may make this solution impractical.

d. Indicator Site Circuit Change

A circuit change was considered that would affect only the indicator site; however, we could not figure out a method of eliminating the false emergency when neither of the two interleaving replies lead or lag. Any circuit change would not be a complete solution.

Test Results

a. Denver Fix

Before the false emergency investigation began at Salt Lake City, a modification suggested by the Denver Regional Office was installed in the RKS system. The modification consisted of connecting the C and D kill pulse circuitry. This fix did not improve the false emergency condition.

b. Code Change Test

A code change test was performed on the Rock Springs ATCBI-3 beacon system to determine if Code 2300 caused most of the false emergencies on that system as suspected. The test was coordinated with the Denver Center in an attempt to eliminate the use of the 2300 code by aircraft flying within a 300-mile radius of the Rock Springs beacon site. A 2400 code was used in place of the 2300 code. A 5-day test was requested with all 2300 codes eliminated for a 2-hour period each

day from 10:00 a.m. to 12:00 a.m. Because of difficulties encountered by Denver ARTCC in setting up the test, the test was shortened to 3 days. A part of the test area (area within a 200-mile radius of the RKS site) was monitored with the PPI. False emergencies were accurately located and counted. It was also verified that Code 2300 was not used within the 200-mile radius area. Test results are indicated below:

Period	Count
22 Sept 71 (Wed)	7
23 Sept 71 (Thur)	0
24 Sept 71 (Fri)	0

Since 30 to 40 false emergencies are normally observed during the Thursday and Friday 2-hour period, it is fairly conclusive that most of the RKS system false emergencies result from use of Code 2300. A higher degree of confidence would have to be established with a longer test period. It was discovered Wednesday evening (after the first day test) that the RML video separator was out of adjustment. The results of this out of specification condition were most noticeable when the raw video button was pressed. Some of the target presentations had tails as indicated below:

Correct adjustment of the video separator eliminated the tails. The out of tolerance condition may have caused the false emergencies observed Wednesday. Adjustments affecting signal to noise ratios or grass levels may contribute to the problem.

Conclusions and Action

a. Conclusion

1. Feedback from the controllers indicates that false emergencies are a serious problem.

2. It doesn't seem possible to eliminate the problem with a simple circuit change.

3. The problem will get worse as air traffic increases. The problem will get worse rapidly when a large number of fighter aircraft are stationed at Mountain Home AFB.

4. Code selection appears to be the best solution.

b. Action

After concluding the need for code changes, we contacted Maintenance Engineering Branch (WE-480) to obtain possible background on the problem and to find out if any attempt had been made previously to change the present code assignments. Upon investigation, we were advised by WE-480 that NAFEC was aware of the theoretical possibility of this problem and would support, on a national basis if required, the elimination of the codes causing the problem. They suggested that we obtain a letter from the Air Traffic Division endorsing the change and they felt that a national code change would be possibly accepted based upon the data and the results of the test that we made.

In addition, since other adjacent Centers likewise use Code 2300 to make the change completely successful, it would require that they likewise discontinue this code assignment. This therefore would require coordination and possible endorsement from the other regions if we are to completely eliminate this problem.

We suggest as a possible alternate that if additional confirmation of our findings is desired that a longer test period could be conducted on the RKS radar system. This would require that the Denver Center again participate in the program as well as other possible users in a 300-mile radius of the RKS system. We do, however, feel that the test results are quite conclusive and that the false emergency problem can be greatly reduced if these code changes are immediately approved.

SUMMARY OF EMERGENCY FALSE ALARMS - WAITING FOR AUTOMATION

by Larry L. Craig, AT-120 (2)

The problem of false emergency alarms has been known for many years. In general audio alarms have been disabled, visual alarms have been ignored by controllers. However, there is no doubt in a controllers mind when an authentic emergency reply is observed.

Electronic fixes for the problem have been designed by NAFEC, and the regions. Had the delay in NAS stage A been known six years ago, a priority F & E program no doubt would have been established to improve the credability of the emergency decoder circuits.

Irregardless, Airway Facilities Service, and its predecessor, Systems Maintenance Service, included several F & E budgets alloting funds for improvements in the system. But none have survised the priorities of the budgetting.

Its the general concensus of opinion that when decoding goes from 64 to 4096 codes, the number of 4096 alarms will be drastically reduced. Therefore the present posture is one of waiting for automation.

To relate to the status of the equipment in the immediate future, bear in mind that all domestic air traffic control centers are to receive NAS stage A. Sixty four terminal locations have, or will, receive ARTS type systems. Twenty six terminals are scheduled for the TPX-42, which has the 4096 type emergency decoding. And all remaining terminal radar systems are included in our budgetary planning for 4096 decoders.

ELECTROMAGNETIC INTERFERENCE WORKSHOP

CONTROL OF INTERFERENCE TO "SECONDARY" SURVEILLANCE RADARS IN THE LOS ANGELES BASIN AREA

by John Kemper, WE-406 (10)

In Frequency Management we quite frequently feel like we are an instruction book because we are called when everything else fails. And it's often not a sense of pride, rather a sense of frustration that we feel. When dealing with a radar problem, we normally are called into a situation only after the screen has gone white and the ATCRBS has been Notammed off the air. What do we do now? In running down these problems we do it on the basis of sound--what we can hear--because that's what we have to use to locate it after we have looked at the radar scope to see exactly what type of interference is appearing.

Hearing the Transponder.

Back in 1962, I was up on San Pedro Hill, a 1400 ft. hill where our long range radar is located, and for another task I was monitoring 1 to 2 GHz. I had a broad-band receiver which covered from 1 to 2 GHz, taking in transponders, interrogators, the "L" Band et al. For a short period, I monitored what was going on and this is exactly what I heard: (Generally quiet. A few "zips" now and then.) Oh, for the good old days when it sounded that way! You can hear just a few here and there, but an average day nowsounds like this: (Heavy transponding. Practically no gaps. Wide range of PRFs.)

I took our Field Strength Meter, a log-periodic antenna and in the last 30 days made a series of recordings that you're going to hear. You can get an idea of what it sounds like because that's the way we have to hear it to find it. Keep in mind that ground-to-ground Radar would be a snap. If we had an "L" Band ARSR problem we could find it in a hurry. But with ATCRBS we've got to look at our receiving point here coming out of the aircraft over there perhaps 100 miles.

A big problem which I'll give you in detail in a moment was the case of a radar 32 miles away from LAX ASR ATCRBS that completely covered our scope with spokes and rabbits making it totally unusable. The environment that we heard at the Regional Office where I was doing this recording--just a couple of miles from our victim LAX ATCRBS--was this: (One steady buzz at 270 PRF. A few other strong "zips" occasionally.)

It looked just exactly like it sounds. Now there are sources that we don't understand, some that come on for 20 or 30 minutes at a time and which we don't hear again, but they give us all a bad time. One of those is the next one I'm going to play for you - anyone will tell you that a simple nodding type of signature is obviously a height finder and everyone knows that there are no beacons on height finders - but when we hear this kind of thing on 1090 MHz, we wonder. (Fairly heavy random transpondings. Predominant "nodding" sound at a low PRF. Nodding rate about 1 nod/2 seconds.) That is not a case of a reflection; both bursts are actually coming through. If you've any ideas we would like to know about them because we occasionally hear these things.

Ramp Testers.

It's a little hard to get one by itself unless you are right on the field or in the immediate vicinity, because there's so much crud on 1090. Remember this is the 1090 coming back. A receiver used on 1030 in any congested area is worthless because there is so much coming out of our own omnis and our own primary interrogators that you couldn't find beans. A ramp tester, along with a military aircraft switching its antenna from top to bottom sounds like this: (Steady low PRF buzz plus a 30 Hz switching circa 400 PRF) It is omni-interrogating everything within 4 to 10 miles depending on the level of power involved.

I have one favorite one. This one I recorded a week ago last Friday at 4:20 in the afternoon. It was at Los Angeles and I call it "Times Square on New Years Eve". (Sounds like Times Square on New Year's Eve--a solid mass of noise.) This was using a 100 KHz band width on a Log-Periodic antenna on the approach to LAX. If we had put an omni antenna on the receiver we probably wouldn't have been able to get it all on the tape.

The intentional ones give us a bad time. They're a little harder to hear but only because of the nature of the pulse generator. Looking at it, we see pulses at extremely high rates with respect to the normal 1090 transpondings. Here's one: (High pitched buzzing or "rushing" sound.)

A week ago last Tuesday the LAX ARSR was shut down for a few hours for some antenna changes. The Maritime environment which had given us much difficulty was clean. All of their interrogators had been shut down after we found them and definitely determined they were the cause of interference. The Navy Ships out in the immediate sea area for some reason were not running their shipboard interrogators--at least not to any degree that we have heard before--and I couldn't resist it! I recorded the quiet. This is what it could sound like if 1030 and 1090 were properly controlled on an average day at 2 o'clock in the afternoon. (Quiet background. Fair number of "zips" at irregular intervals, various PRFs.)

PRF Coincidence.

One very nasty problem occurred a few weeks ago. The LAX ATCRBS was devastated on both sides of the defruiter. You heard what it was on the third tape a few minutes ago: It was intermittant, and we spent considerable time on it with practically no results. We went to our high monitoring sites and tried to find something that matched the 405 PRF that the LAX ATCRBS has. We heard all kinds of crud, but we couldn't find anything that matched the 405. So, eventually in desperation, we set up an arrangement with the ASR whereby they would call us as the intensity of the interference waxed and wanned. At this time I went back to the R.O. and monitored with our equipment there. After a few hours we began to see that a certain PRF kept coming up and down regularly and matched what LAX was telling us was telling us was a heavy interference environment, I measured the transpondings at 270. Now what has 270 to do with 405? After a little reflection I noted

405, 270, and 135 rang a bell as a 3-2-1 ratio. Every time that LAX fired three times and a 270 PRF fired two times, they coincided. Figure 20 will show you timewise how all this works out. We found the source 32 miles away--a TPX-28A operated by MATCU-74.

Just by turning a shaft available on a TPX-28A, in the mode that is controllable, the blocking oscillator's PRF goes up and down. At 270 it completely clobbered LAX. Later on we made some tests at 405 and several other tests, getting some very wierd results. Unless we got right on 405 we have run as long as an hour and 5 minutes with no interference at any one of those PRF which had caused us problems. Then suddenly it just went wild! We saw nothing but a mass of stuff, and no matter what we did, we couldn't stop it.

Power Attenuation.

We have a test February 15 which we hope is going to help us. We're going to be using the same radar involved. ECAC will be there. The Western Area Frequency Coordinator will be there with his van. They're going to try to force the thing into interference by running it until it causes interference, then replacing it with another identical radar in the same spot using the same antenna. (Of course there are two antennas on the 28 series, but they both caused interference).

At the same time, we're going to be looking at the ATCBI-4 at El Toro about six miles away and at Long Beach, a ATCBI-3 with a PRF of 415, trying to get some reason for this happening. It doesn't work the way it should, and we don't know why. At times we just get completely wiped out. We did find that if MATCU-74 put in 12 dB attenuation in the antenna, they were able to run their mission without any degradation whatsoever. And we saw no interference. But the attenuator they had was a test affair. It got so hot that they couldn't stay on the air. As a result, they're off the air trying to get a suitable attenuator. This is one of the reasons why I asked Pete (Lt. Col. N. F. "Pete" Williams, DOD Rep. to NATO Comm. for European Airspace Coordination) yesterday about the marvelous $30.00 power reduction kit the Europeans came up with. It looks like they're five years ahead of us, and it would seem to me that Paris should get that type information out to the Military in the field in CONUS. If MATCU-74 had it now they could ... back on the air. As it is, they're off the air, and they will have to stay off until they can solve their problem.

I hope that from the minutes of this symposium or through other means the power reduction kit information will get to the appropriate Military facilities out in the field, because the time is here where we have to say "You can't operate if you cause interference. Start attenuating." And in all new cases, there will have to be means to attenuate before we put them into the environment.

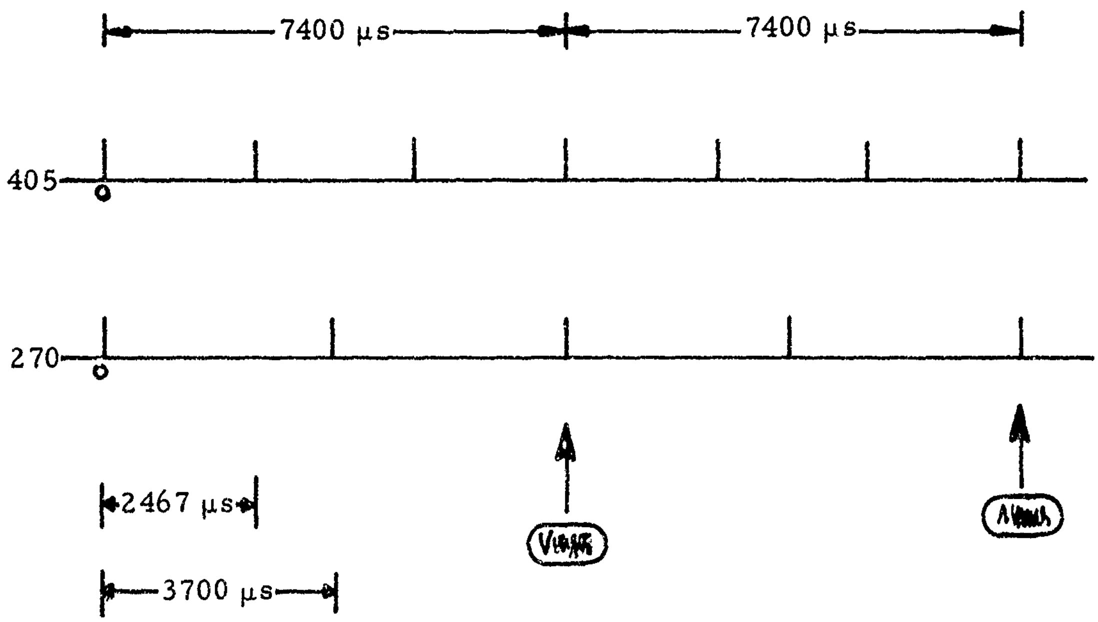


FIGURE 20. COINCIDENCE OF THE 405 AND 270 PRF'S

A Couple of Cases.

We've had so many different types of cases that it's impossible to get into them all, but very briefly, two others may be of assistance in understanding the problem.

Our BORON Long Range Radar ATCBS got clobbered. It uses a 350 PRF. We found after a lot of work and some assistance by AFCS, that a UPX-7 with two KW feeding an antenna on an 80-foot pole was being used for a ramp generator. The Sargeant on duty was very cooperative. We asked how often it was used. He told us he turned it on in the morning, and since the flying doesn't quit until the afternoon, left it on and didn't turn it off until evening. Free-running, it would drift through our PRF every so often. That's kind of tough to find, because when you're out in the field with a van measuring and looking, you're beating your head against the wall trying to find a specific PRF.

Talking to the radar, they report how bad the interference was. It was horrible an hour ago, but they hardly see it now. It turns out the source didn't turn off; the PRF has only shifted 3 or 4 PPS.

Another problem which affected our Paso Robles ATCRBS turned out to be a standard MPN-15 series GCA where the countdown had slipped from 4 to 3. Instead of 275, the PRF came out 366. Our Paso Robles Radar at a PRF of 365 at 178 miles away gave ghosts and false targets whenever the antenna azimuth rate coincided with the MPN-15.

If there are some questions, I'll be happy to answer them during the regular question period.

I hope that you get the feeling that we're concerned about 1030 and 1090. The whole NAS system depends on it, and right now, it scares me to death.

DIGITAL SIMULATION OF RADAR BEACON SYSTEM

By Lou A. Kleiman, TSC (12)

Let me tell just a little something about TSC which is the transportation Systems Center. TSC reports officially through Dr. Cannon to the office of the Secretary of Transportation. So we're somewhat to OST, as NAFEC is to FAA.

About 30% of our budget, and roughly 30% if our manpower is devoted to FAA projects. So we're pretty heavily into FAA problems.

We used to be a NASA Center, so we're not totally new to the game. We were dealing with a number of problems before TSC came into existance.

About a 1 1/2 years ago, July 1970, we began to support Marty Natchipolski in RD-242, the beacon section, and Joe Herrmann, who is now OP-4, worrying more about interference problems. We had so many problems, that Joe and Marty in particular wanted to look at, that it became apparent that the kind of effort that we would be involved in would be extremely detailed.

Sometimes you can analytically formulate a problem, but when you get into a system as complex as the beacon system, the results that you get aren't always intuitive. In fact, sometines they are quite counter intuitive.

If you raise side lobes you should raise fruit levels - right? Well sometimes that's wrong, because you may in fact, by raising side lobe levels, as we found out not too long ago, artificially implement improved interrogator side lobe suppression. In other words you're suppressing more of the transponders more of the time and your actually reducing fruit to some point.

Using Simulation.

Thats just one example of a counter-intrutive result rectified by performing a simulation. Instead of writing down a set of equations, lets just reproduce, whats going on in the system, and that's the effort we've been involved in for a period of time.

We are pretty much out if the developement phase and into the application phase now.

We've been to an International Airport, and vicinity, and seen a problem at Palmdale with the defruiter, and we experienced some rather frightening spokes, also some ring-around.

The controllers claim that this isn't so bad, at least the ones at LA Tower, however I had to assure them that when the automation system gets in, both the CD and ARTS III will be tied into this particular radar, the BI-3 will be feeding Palmdale, and it would get better.

One of the things I was doing while I was at Los Angeles was trying to get traffic data for the simulator, and as I sat at the scope it was rather impossible at times to track some of the targets through the noise.

One of the things I did was to sit at the CD maintenance console and I observed a phenonenon that I call "square around" (Figure 21): there were a number of targets that the CD has a problem handling with that particular radar that have a ring around at about 5 miles from VORTAC, so that tracking targets, beacon targets, digitized declared targets apparently, through that noise it becomes somewhat difficult. So clearly, one of the things we'll be looking at is some of the leading and trailing edge criteria for the CD as well as for ARTS III in the LA area.

There are three things that we want to do with this simulation:

1. Hardware - The antenna improvement programs that Marty Natchipolski is looking at.

2. Policing and management, That's Joe Herrmann. That's getting into the interference problems - Jerry Markey.

3. The hot spots and problem areas, which is pretty much integrate with 2.

Simulation Philosophy.

The simulation flow is much like the system itself. The philosophy behind the simulation is: let's do whatever the beacon system does, once per sweep for the radar. We're gonna freeze time for every PRF, so the antenna's fixed and sends out the interrogations. All the interfering antennas send out their interrogations, including mode-interlace, if they happen to be running it at the time, and everything goes up to individual aircraft, individual transponders. All the capabilities are there, and whatever we're looking at, we try to set. This is given as input to the program.

Simulation Method.

The program structure is completely flexible. It can be simplified by bypassing areas that we may not use, or we may not chose to look at at a particular time. If we're running downing parameters, looking at the CD and how we make it better if we can determine all the up link pulses, we look at their arrival times and powers, tabulate it, dump it onto a disc on a computer, or a tape, or something and then read that into the CD or ARTS III or TPX-42, or whatever we have to be looking at on the downlink side, and then just play that downlink data in time after time, and look at the various parameter switches, leading and trailing edge criteria, and so on, on those particular processes.

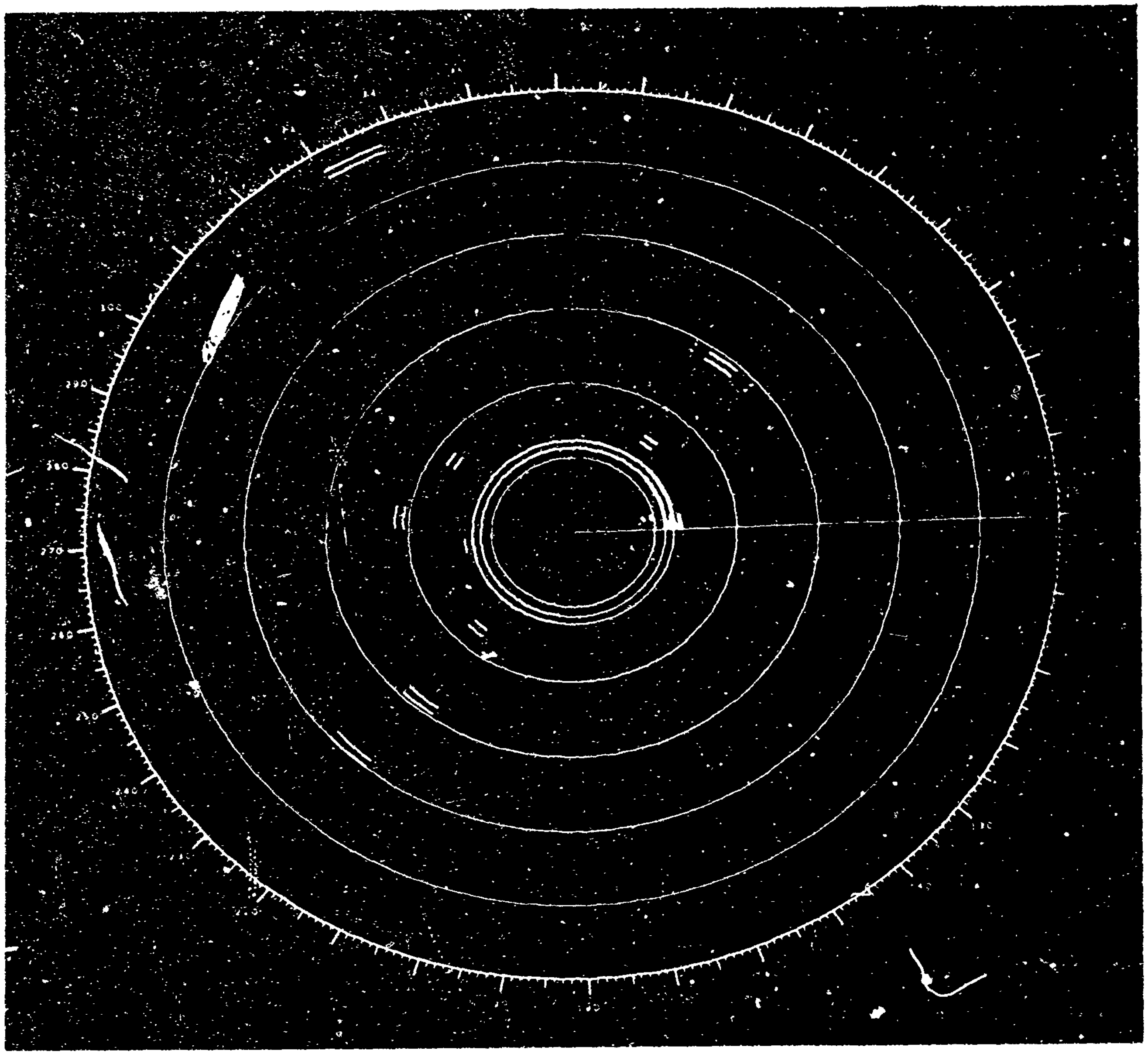


FIGURE 21. AN EXAMPLE OF "THE SQUARE ROUND" PHENOMENON AT THE CD MAINTENANCE CONSOLE

The flow includes initialization (Figure 22), which is primarily the interrogator data that we get primarily from ECAC, and validates, substantiates, and compliments through onsite investigations. The air traffic data that we got somewhat difficultly at LA. But the CD was really a godsend because I could sit there and track targets and get pretty accurate readings of range and azimuth as a function of time.

We extract from position, the velocity if the aircraft, and the attitude of the aircraft. We put real antenna patterns on the aircraft - at least as real as we could obtain from measurements or from the field - and fly those in the simulation.

The simulation is only as good as the input we give it. We update time and traffic each time through the sweep of radar, unless that particular parameter doesn't have to be updated that often. Actually we don't update aircraft position that often, only every 20th of a second.

We determine interrogration times from all the ground interrogators. We do all the uplink alterations. There's an interrogator receiver antenna, side lobe suppression antenna, with separate patterns vertical and horizontal - space loss, the aircraft antenna, and finally we get into the aircraft, and we have various models of transponders. They do different things depending on type, and we repeat for all the aircraft being interrogated by all the ground interrogators.

We came out with an array of pulses on the downlink that are attenuated in the same way down. We determine the arrival times, bracket decode, and our CD model is just complete. We'll be getting into ARTS III, and do the same thing over.

You can see there's a lot to do in 2 1/2 milliseconds, which is the cycle time of a 400 PRF.

Problems.

We have many problems to do; O'Hare, Jacksonville, Washington, San Fransisco, Miami, New York, and Atlanta.

To give you a typical example of who's causing what problems; there are 44 unclassified interrogators in the ECAC file within a 200 miles of LAX. There are also 12 secret, 5 confidential, and who knows how many that we don't know about.

When we do a simulation in a region, there is some information that we need. We need:

1. Rotation Rate
2. PRF
3. Initial Start Times For The Azimuth Of The Interrogator
4. Transmitted Power
5. Latitude
6. Longitude

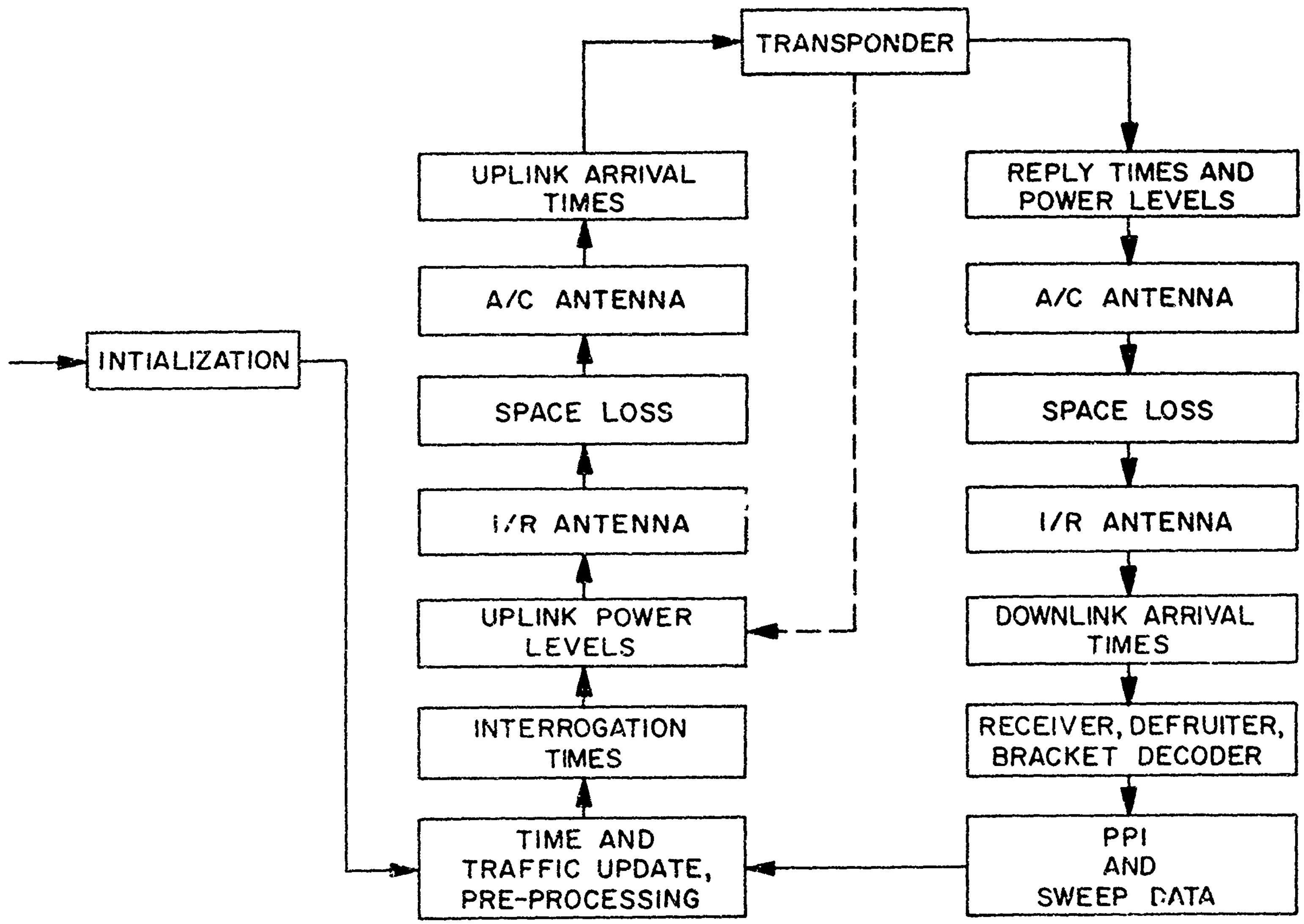


FIGURE 22. THE SIMULIZATION FLOW

7. Antenna Height
8. Site Elevation
9. Start Time For Interrogator
10. The Level Of P_2 below P_1 without SLS
11. Mode Interlace
12. Antenna Gain
13. Improved Or Normal SLS

This is a reasonably complete list of the parameters that we use.

One of the things we're doing for LA is to take the line if site attenuation charts due to buildings, mountains, what have you, and we blank the antenna pattern below a given altitude for certain azimuths, as a function of range so we will have blockages, and we can also include reflections in the same way.

Simulation Magic.

Through the magic of simulation I was able to move Maxwell Air Force Base over to a mile north of Atlanta at minimum cost. So we lined that up, and Atlanta was operating at a 390 PRF, while Maxwell was running at 400. Every 10th of a second, which at 15 rpm os 9°, Maxwell put out 40 interrogations, and Atlanta put out 39. So the result was that every 9°, something would happen and could recur in time. And in fact what happened was that Maxwell was interrogating a particular aircraft all the way around - I think we had SLS off in this particular case - and Atlanta was open for this particular reply every 9°.

When we switched side lobe suppression on, we observed, very few responses, if any, from the side lobes. We did get a target breakup on the main lobe due to the same phenomenon.

We're going to show you a film now, and I hope it will give you an idea of the realism of the simulation. We're going to show you three film segments:

We're going to change the STC, switch the defruiter on, put everything back off, put the defruiter off, then switch the SLS on. We're going to look at some switches and see what happens.

We're going to have an overflight. The overflight is up 5 miles, so the radar is going to display him out 5 miles even though he's flying just about a mile north of Atlanta.

Then finally were going to show a less dramatic effect of the antenna patterns. We hang to aircraft out at minimum cost, on balloons or helicopters or whatever, and rotate them from plus 90° to minus 90°, one in pitch, the other in roll, so you'll see the effect of the antenna patterns, as well as the effect of these two fixed aircraft.

This is Atlanta; it's simulated. We use a computer to drive the CRT.

INVESTIGATION OF ELECTROMAGNETIC INTERFERENCE BY AIRBORNE MONITOR

By George F. Spingler, NA-120 (13)

My topic this morning will cover electromagnetic interference problems that were investigated by NAFEC in the past and the design of equipment that will be used by NAFEC to investigate field problems in the future.

Beacon Monitoring.

In 1966, a request was sent from SRDS to the Flight Inspection Branch requesting that a radar beacon monitoring facility be added to their normal flight inspection equipment configuration. Prior to this request, the SAFI equipment was used exclusively for the purpose of obtaining data on the operation of the ground based TACAN and VOR navigational aid stations. In order to implement the air traffic control beacon system monitor, a red indicator lamp was connected to the reply rate limit circuitry of a TRU-1 Transponder and the light was added to the flight console. Whenever 1,000 interrogations per second were exceeded on Mode 3/A, in the TRU-1 Transponder, the red indicator lamp was energized. The operator seated at the SAFI console was instructed to record the "operation number" each time the light came on and also when the light went out. In this manner, the geographical areas were identified in which interrogations of the airborne transponder exceeded a rate of 1,000 interrogations per second.

A report was made to the Beacon System Interference Problem Subgroup at the end of each SAFI flight to indicate the areas where overinterrogation occurred. These data were inserted on a map of the Continental United States for review by the Beacon System Interference Subgroup and the progress of each overinterrogation area was followed by the subgroup to determine if the overinterrogation persisted (Figure 23).

When certain areas such as Los Angeles and New York became repeated offenders, a need arose to determine the cause of this overinterrogation.

NAFEC Airborne Monitor.

In May of 1969, a request was received by NAFEC from SRDS requesting that an ATCRBS airborne monitor be implemented to investigate the SAFI overinterrogation areas to determine the reason why they existed. An airborne monitor system was fabricated at NAFEC whose design centered around the fact that even though each interrogator operated on the same interrogation frequency of 1030 MHz, the PRF of each interrogator was different within a large geographical area (Figure 24).

Since the PRF of each interrogator was different, this became an identifying feature or "signature," which could be used to separate the numerous interrogations received in the monitor aircraft into groups of interrogations associated with each interrogator.

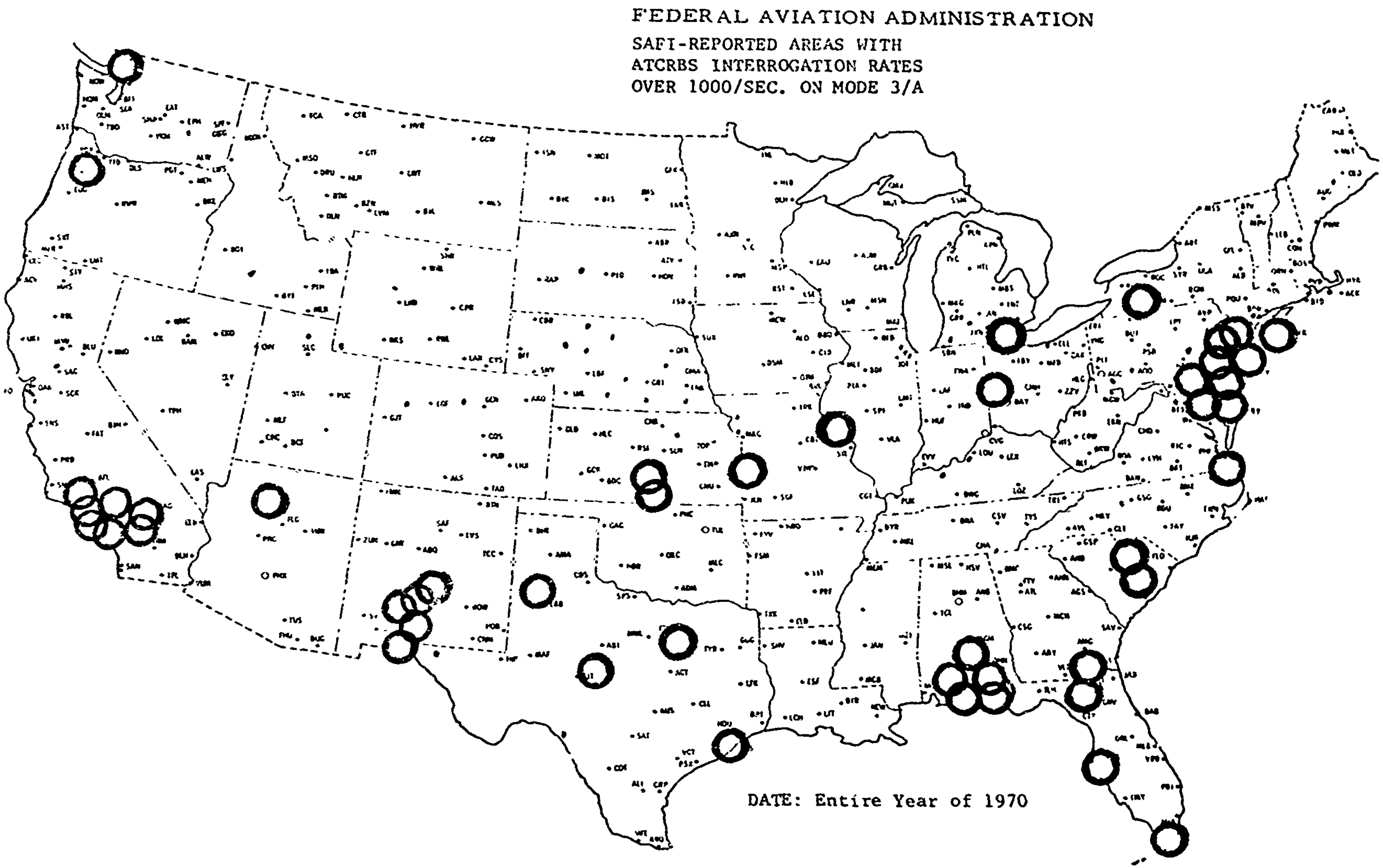


FIGURE 23. AREAS WITH BEACON INTERROGATION RATES OVER 1000/SEC ON MODE 3/A

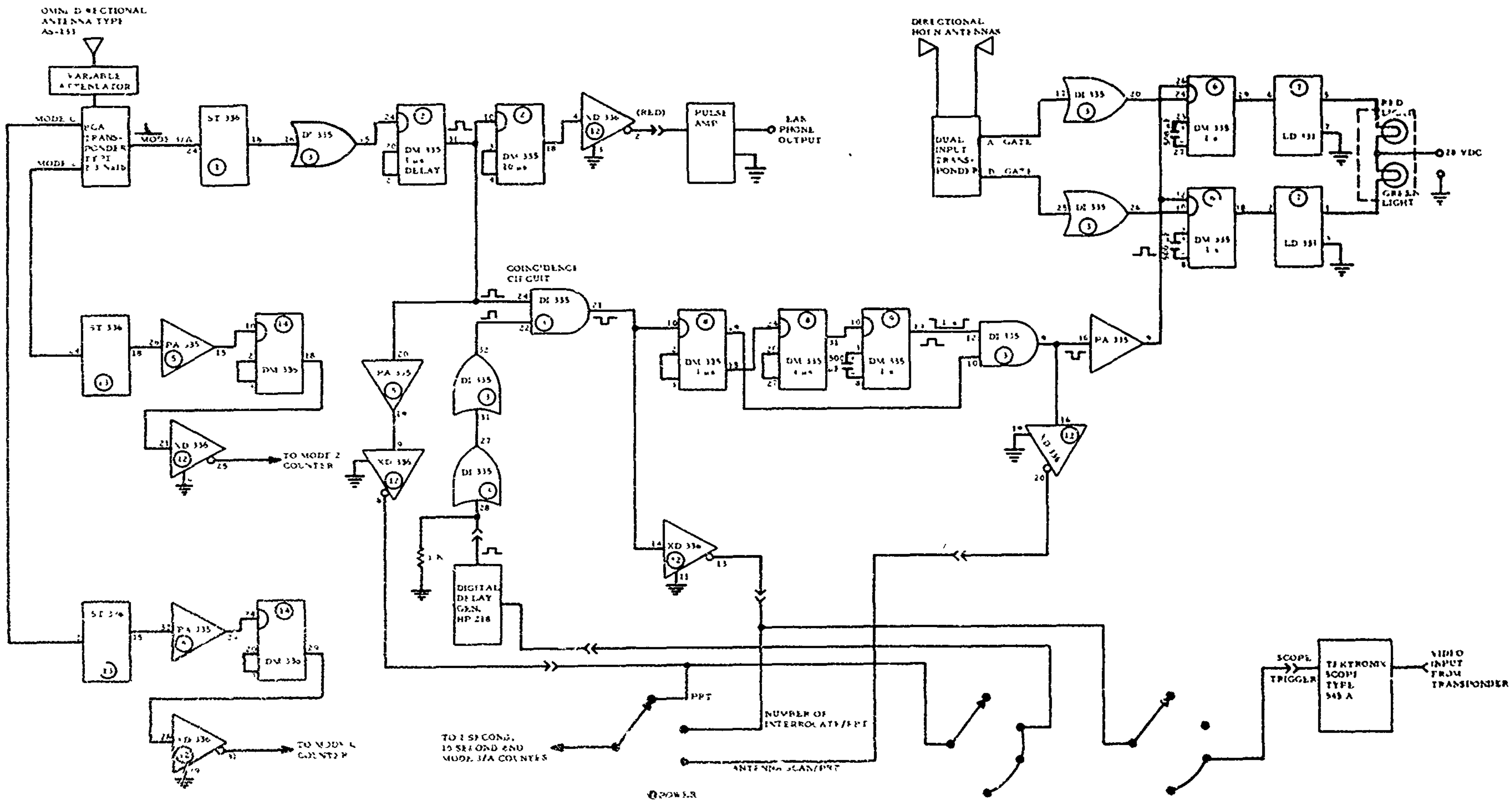


FIGURE 24. DIAGRAM OF THE NAFEC AIRBORNE MONITOR

The rotation of the interrogator antenna also provided a means by which the interrogations could be grouped and become identifiable.

During the shakedown of the airborne monitor system at NAFEC, some problems were uncovered on one of the radar beacon sites at NAFEC. Antenna patterns were made of the radiation from the Eastern Region's ASR-4 and it was discovered that the SLS radiation was missing. An inspection of the site showed that the omni-directional antenna coaxial fitting was "cross threaded" and that the antenna had not been functioning since it was installed six months prior to this date.

A shift in the PRF was also noted, using the new airborne monitor system, when the channels of the ASR-4 radar were changed. This was traced to a defective delay line heater in one of the channels of the radar. Both of these problems were unknown to the maintenance personnel at the site, but were readily detected by the newly devised monitor equipment.

New York Flight Tests.

After the shakedown tests were completed at NAFEC on the new equipment, flight tests were conducted in the New York area. The New York area was selected because it was close at hand to NAFEC and had been reported by SAFI to be an area of overinterrogation.

The results of the flight tests in the New York area showed that the maximum interrogation rate measured at the time of this test was only 600 Mode 3/A interrogations/second, while the average rate was only 400 interrogations/second. This was well below the 1,000 interrogations per second limit which was considered the start of overinterrogation.

Most of the interrogations in the N. Y. area were due to interrogators which were not equipped with SLS. From the PRFs gathered during the flight test and Frequency Management records, the identity of the interrogators which were not equipped with SLS were found to be La Guardia and Floyd Bennett Field. From the New York area tests, it was evident that just knowing the number of interrogations per second on Mode 3/A was not sufficient. It was necessary to know the number of interrogations contributed by each interrogator, and the source of the interrogations.

Directional Antenna.

In November of 1969, the design of a directional antenna was completed at NAFEC for addition to the airborne monitor system (Figure 25).

The antenna system, utilized a Dual Input Transponder, which operated a red and green light in the cockpit of the aircraft to direct the pilot left or right in the direction of the interrogator. The antenna system was installed in NAFEC Aircraft N-249 in December of 1969. The directional antenna system was then taken to the New York area and field tested to determine how well it could locate the source of an interrogation.

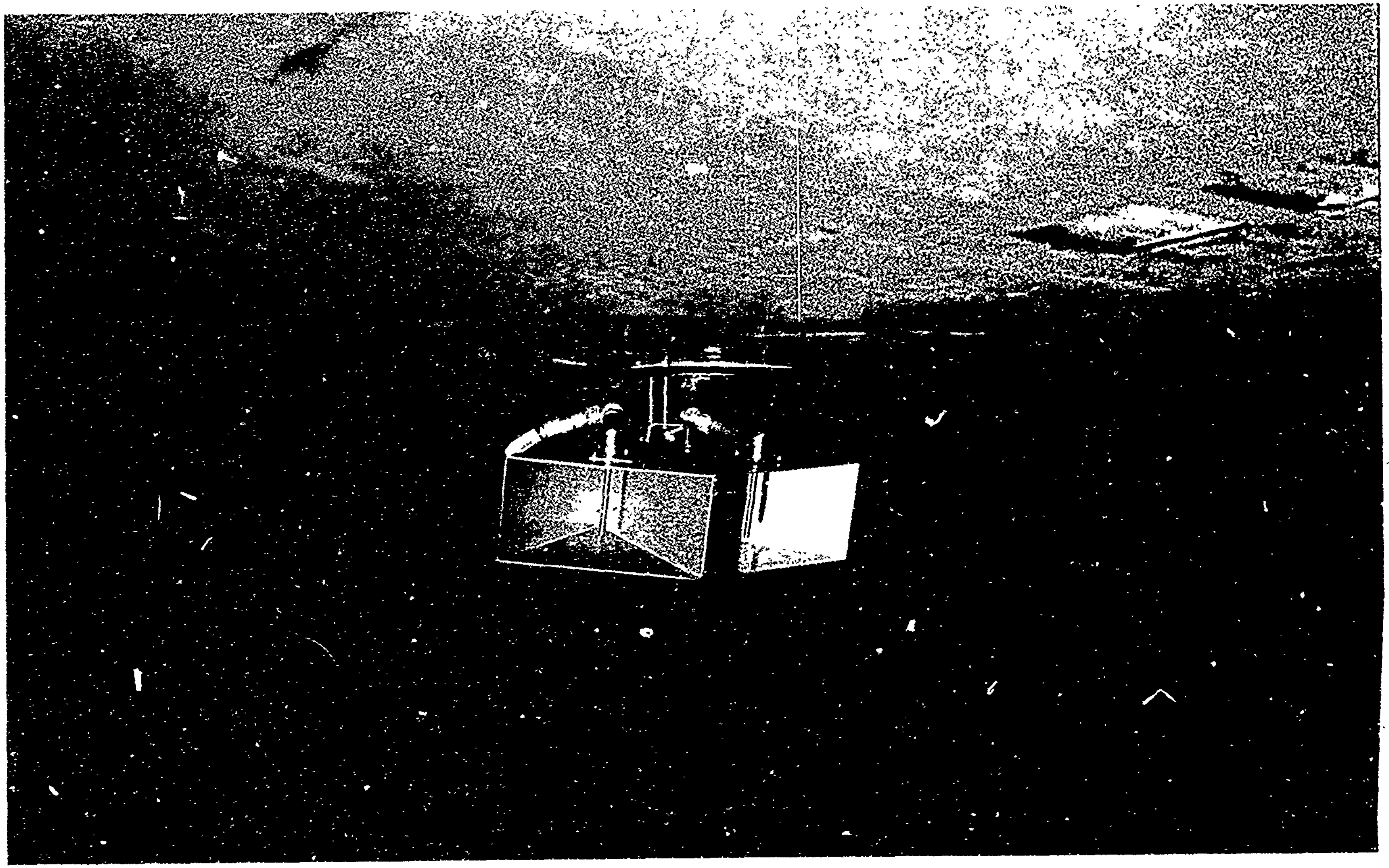


FIGURE 25. AIRBORNE ANTENNA TO FIND HIDDEN INTERROGATORS

During the flight tests in the New York area, numerous interrogators whose PRF were known were used to check out the directional antenna equipment. After the proficiency of the equipment was established, the PRF of unknown interrogator signals were tracked to their source. In order to accomplish the tracking, a variable attenuator was placed in the input coaxial line of the transponder and the attenuation was increased until just the main beam of the interrogation antenna pattern was able to be measured. In this way, the antenna rotation time of an interrogator was measured and signal strength changes which indicated a station crossing were identifiable.

During tests in the N. Y. area, one of the interrogators became very noticeable because it produced an erratic PRF when measured (Figure 26). This interrogator's pulse repetition frequency (PRF) varied over a period of 100 s and was tracked to the Grumman Aircraft Co. Hangar on the Peconic River Airport. The reason for the erratic PRF was later found to be caused by the mode of equipment operation used. The equipment was a surplus ATCBI-2 obtained from the FAA, and was operated on an internal trigger. Since there was no defruiter used with this equipment, the PRF of the system was determined by the internal multivibrator circuitry of the interrogator, which was very erratic.

Since the time of these tests, the ATCBI-2 equipment has been replaced at the Grumman Aircraft Co. with a newer Zenith ZRC-23 Transmitter-Receiver, the PRF of which is very stable.

Chicago Flight Tests.

In March 1970, the airborne monitor system was flown to Chicago O'Hare Airport, and limited flight tests were conducted in the vicinity of the Chicago ASR-4 Radar Beacon Site. These flight tests were conducted to determine the cause of the fade out of transponder replies in the Chicago O'Hare area. The fade out of transponder replies to interrogations from the ASR-4 was traced to vertical lobing caused by multipath propagation from smooth terrain close to the interrogator. During these flight tests, reflections from the remote transmitter site towers adjacent to the ASR-4 were also measured. There were four remote transmitter site towers and sometimes as many as four reflections appeared along with the normal beacon reply.

A report was written on the results of the flight tests that were conducted in the Chicago O'Hare ASR-4 beacon coverage area. The report recommended certain fixes be installed to eliminate the vertical lobing problem and that the remote transmitter site towers be removed from the vicinity of the ASR-4 Site. The Central Region decided that they would wait for the installation of the new ASR-7 rather than modify the existing site.

Dover Flight Tests.

In May of 1970, a request was received from SRDS to investigate a problem of overinterrogation uncovered during SAFI flight checks in the vicinity of Dover, Delaware. Numerous flight tests were conducted in the area of Dover, Delaware, to determine if the overinterrogation still existed at this time.

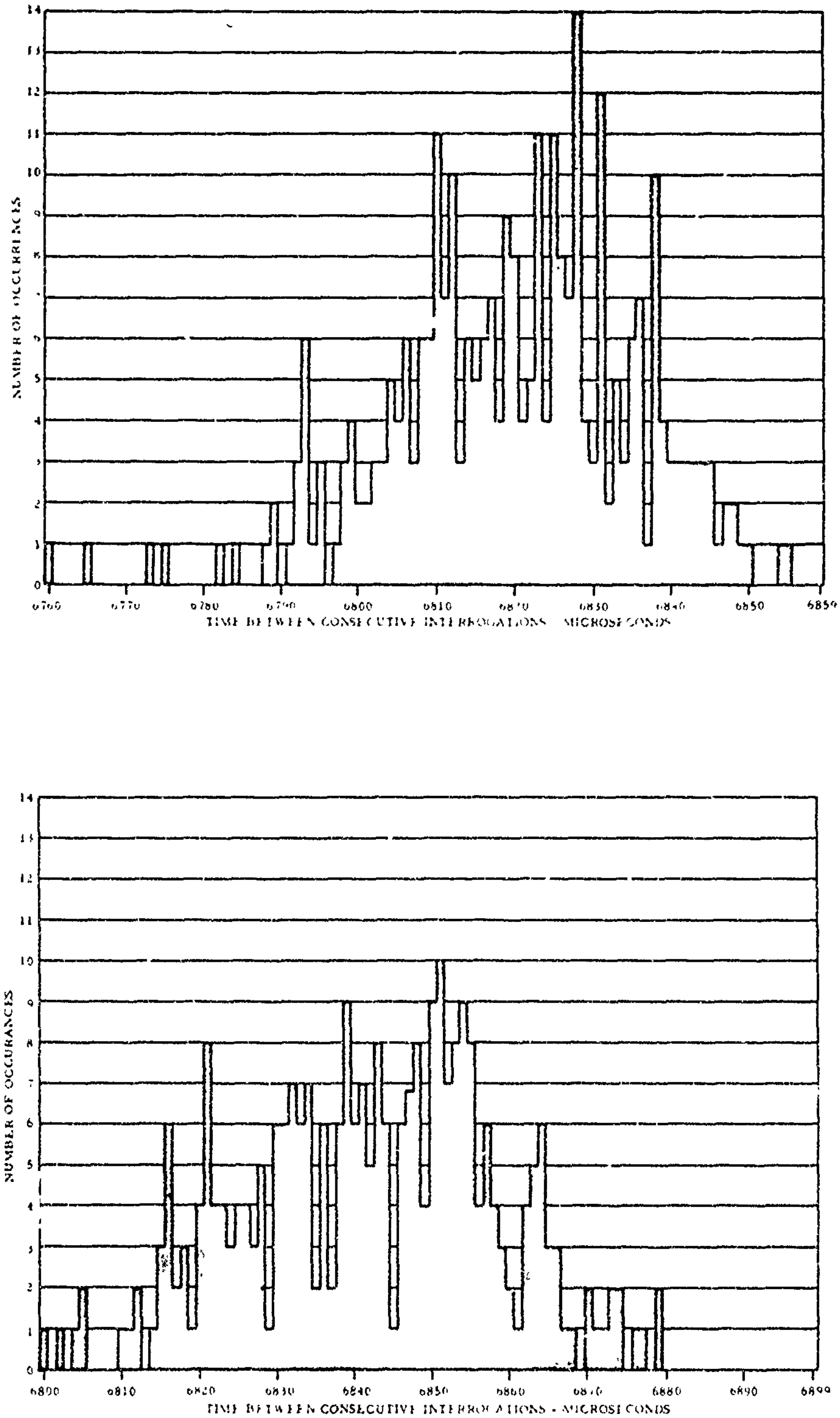


FIGURE 26. ERRATIC PRF IN NEW YORK CITY AREA

During one of these flight tests, overinterrogation was measured, but a short time later when the flight test aircraft was flown through the same air space, the overinterrogation no longer existed. Even though the over-interrogation was never again recorded, a very high number of interrogations were noted in this area on a PRF of 365.5. The directional antenna system of the aircraft was used to track down this PRF which was found to be eminating from the Dover, Delaware, Air Force Base, GCA, (Figure 27).

Trevose Flight Tests.

Approximately four weeks later, a near synchronous fruit problem was reported to NAFEC involving the Trevose, Penna., ARSR Site. The Trevose PRF was 365, and was extremely close to the PRF of 365.5 recorded for the Dover Air Force Base, GCA, a month prior to this. The similarity between the PRF for Dover and Trevose was reported to Frequency Management in Washington. When Dover was contacted about the possibility of interfering with Trevose, they assured the Frequency Management office that they were operating on their correct PRF of 275. When the interference persisted, Trevose contacted Dover and asked that they shut down their equipment for a test. When the Dover Air Force Base GCA radar beacon was shut down, the interference at Trevose disappeared. Later it was found that the interference was due to the Dover Air Force Base GCA MPN 14 counting down approximately 3 to 1 from a PRF of 1100 instead of the normal 4 to 1 count down which would have produced a PRF of 275.

In September of 1970, further interference was experienced at the Trevose site. The airborne monitor system was flown to the vicinity of Trevose to determine the source of this interference. The source of the interference was traced to the Willow Grove Naval Air Station and to McGuire Air Force Base. The McGuire Air Force Base was equipped with an MPN 14 radar, which had previously been the cause of trouble between Dover and Trevose and neither site was equipped with SLS. The reason for the interference was found to be caused by near-synchronous fruit from McGuire and excessive fruit generated by these two non-SLS equipped interrogators.

Even though the airborne monitor system has been successful in tracing the sources of interference, the airborne monitor system was limited in its operation. The system was not capable of recording each interrogation because of the electronic counters and printer used, and there was an ambiguity problem with the directional antenna system used to locate the interrogators.

Airborne Beacon Interference Locator.

Because of these limitations, the Airborne Beacon Interference Locator (ABIL) System was designed (Figure 28). The ABIL System was designed to record all interrogations and side lobe suppressions that occurred in the aircraft as it flew through an area of space.

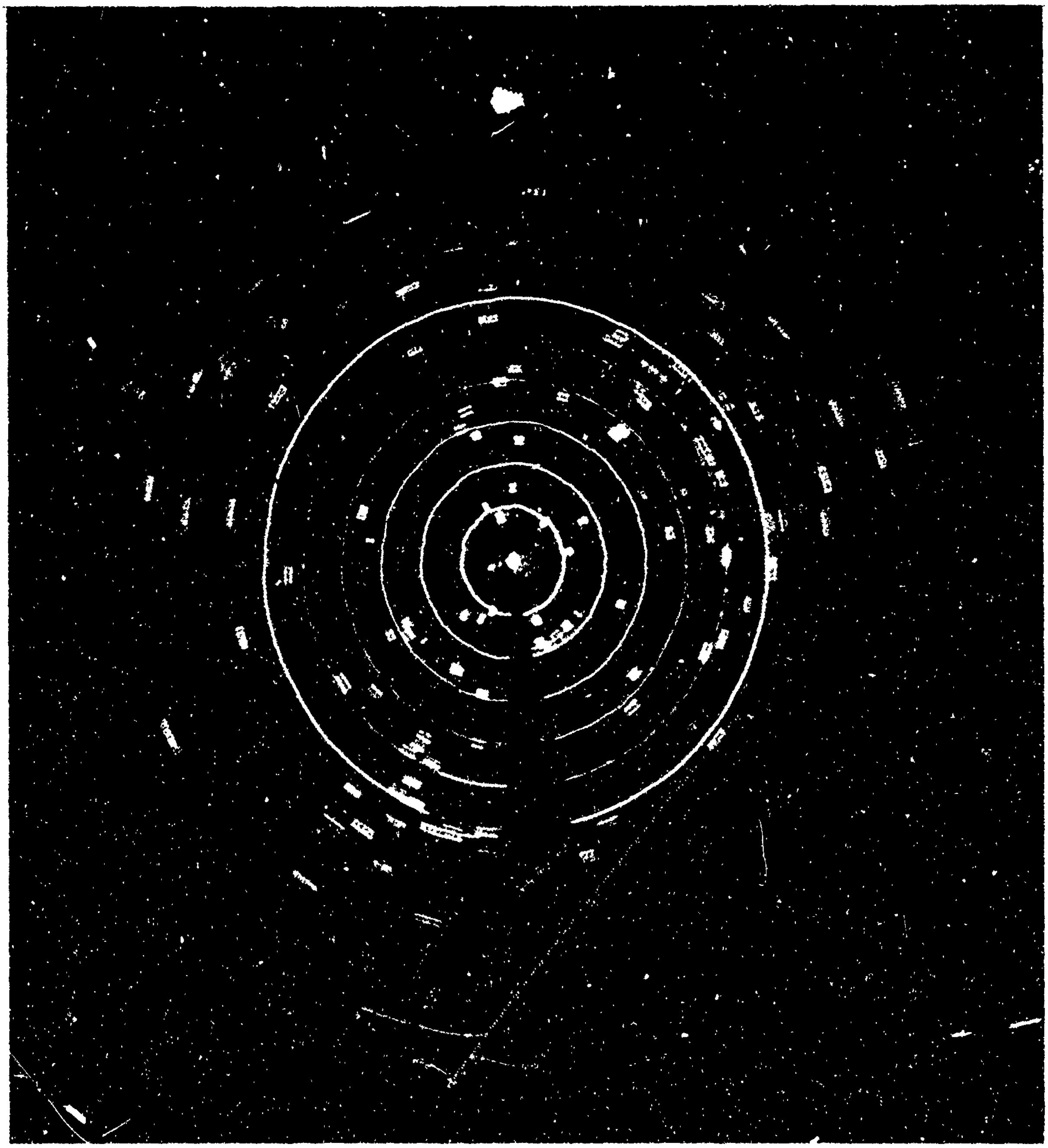


FIGURE 27. OVERINTERROGATION EFFECT AT DOVER

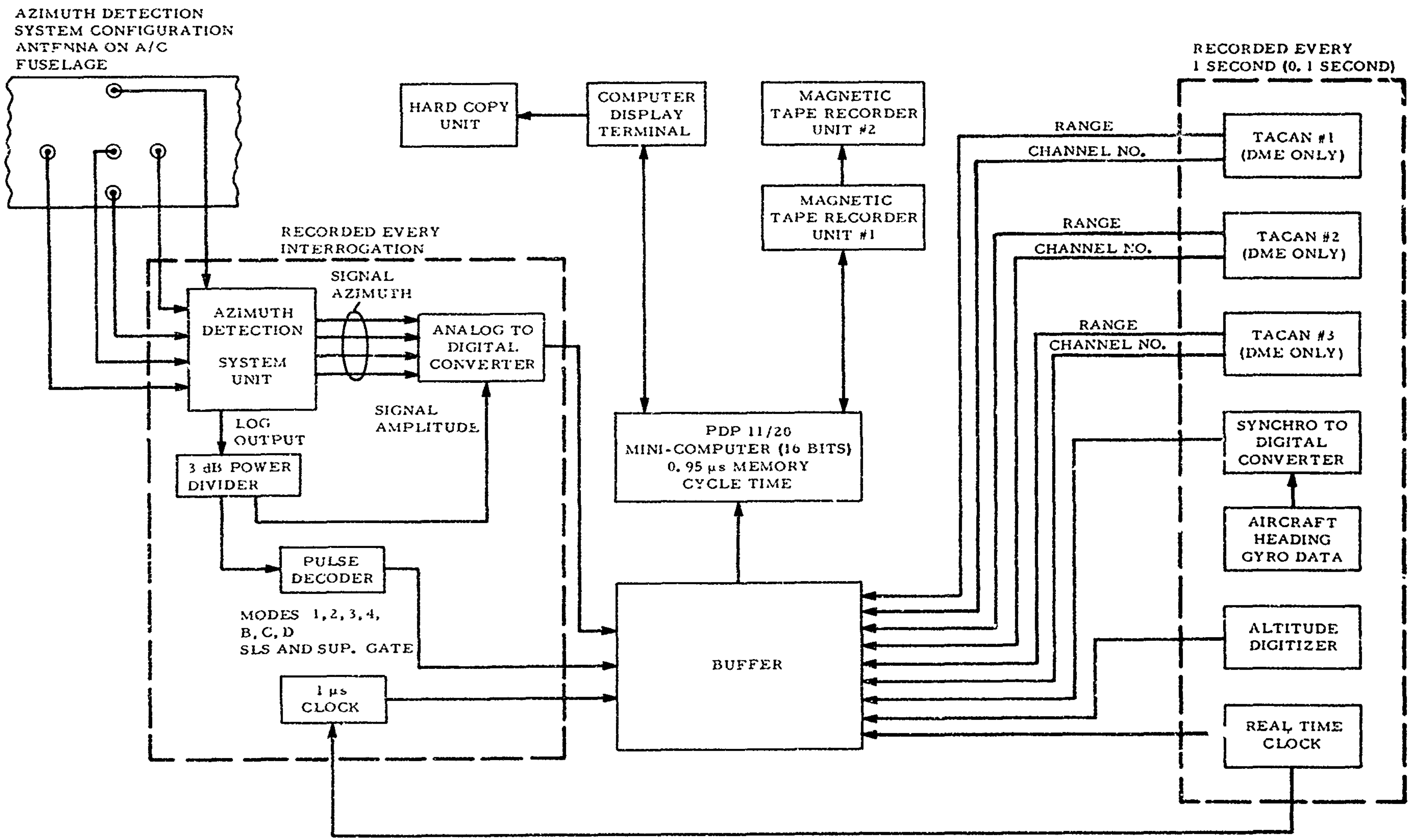


FIGURE 28. DIAGRAM OF THE AIRBORNE BEACON INTERFERENCE LOCATOR (ABIL) SYSTEM

The ABIL System will be installed on NAFEC Aircraft N-103 Figure 29) a Convair 580. The ABIL System will be capable of operating in two modes:

Mode 1 - will allow the ABIL System to record data on magnetic tape during a flight test for reduction and analysis on the ground using an IBM 7090 Computer.

Mode 2 - will also be used to record data on magnetic tape during a flight test, but the tape will be played back and the data analyzed while the aircraft is still airborne, so that the results of the data can be acted on.

Two types of data will be recorded by the ABIL System. Data will be recorded on every interrogation or side lobe suppression; and data will also be recorded on the aircraft positional and attitude information. The aircraft positional and attitude information will be recorded every one-tenth or one second depending on the requirements. Part of the positional data sensing equipment will be TACAN equipment utilizing "DME only" circuitry to determine the location of the aircraft relative to three TACAN sites (Figure 30). The reason that three ranges from TACAN sites will be used in lieu of range and azimuth from a single site is that the azimuth TACAN data are extremely difficult to digitize for the computer and that errors in the azimuth system can be rather large. The three ranges are required to eliminate ambiguities in position that would result from recording the ranges from just two TACAN sites.

Since the latitude and longitude of each TACAN site is known and the ranges from each of the three TACAN sites will be recorded, the latitude and longitude of the aircraft can be computed.

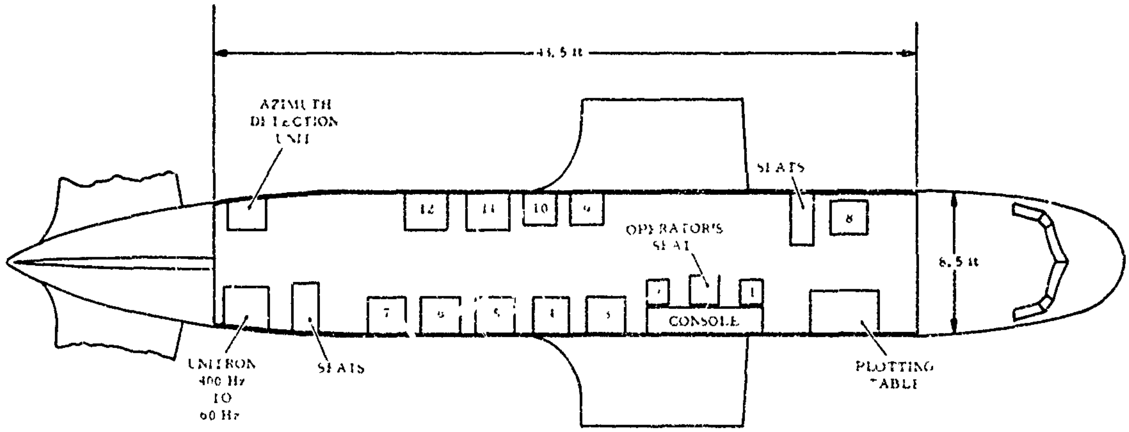
Part of the ABIL system is an Azimuth Detection System which will be used to determine the azimuth of each interrogation relative to the heading of the aircraft. By taking two bearings to an interrogator from the aircraft, at two positions in space, the actual latitude and longitude of the interrogator can also be computed.

Search-Lighting Problem.

One problem that could arise when trying to determine the latitude and longitude of an interrogator would be an interrogator that was search-lighting. Search-lighting is a condition where the antenna rotation is stopped and interrogation is continued at a single azimuth.

If such a condition existed at an interrogator site, the interrogator would only interrogate the flight test aircraft along a particular azimuth.

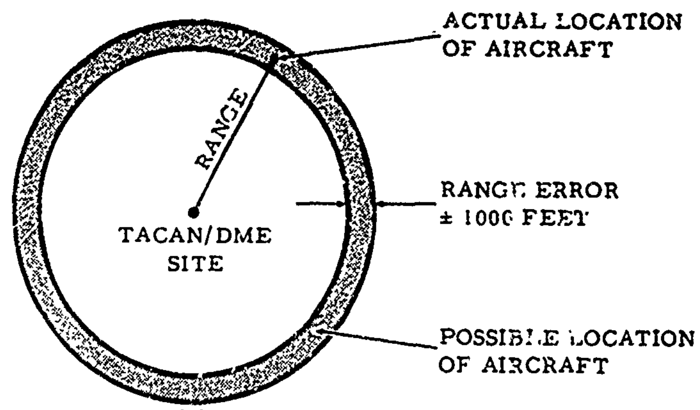
As soon as the flight test aircraft flew on and flew out of the site azimuth on which the antenna was positioned, interrogations would no longer be received from the interrogator site, and it would become almost impossible to determine the latitude and longitude of a site under these conditions by



EQUIPMENT FOR AIRBORNE BEACON INTERFERENCE LOCATOR (ABIL) SYSTEM INSTALLATION ON AIRCRAFT NAN-103

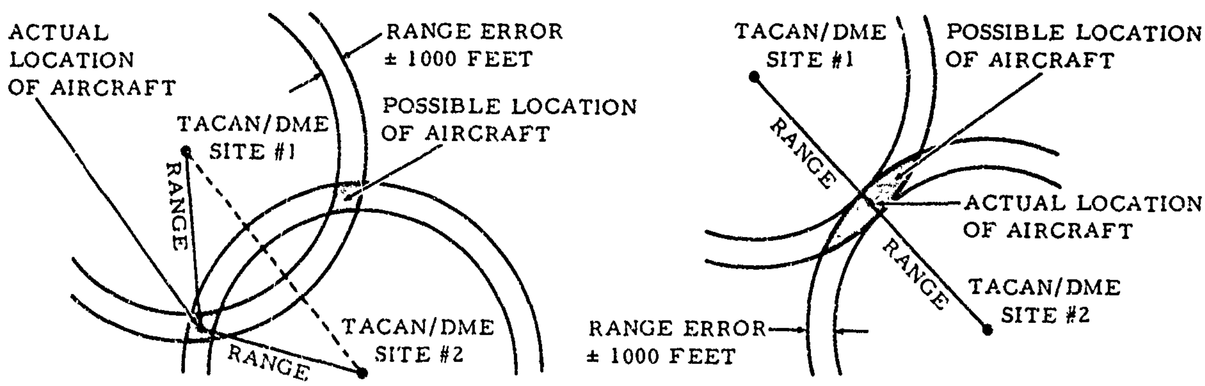
1. TEST OSCILLOSCOPE
2. COMPUTER DISPLAY TERMINAL
3. MISCELLANEOUS EQUIPMENT RACK
   - A. TOP SHELF COMPUTER DISPLAY HARD COPIER
   - B. MIDDLE SHELF CLOCKS
   - C. BOTTOM SHELF POWER SUPPLIES
4. LOGIC INTERFACE EQUIPMENT RACK
   - A. TOP SHELF LOGIC EQUIPMENT
   - B. MIDDLE SHELF ADDITIONAL LOGIC AND SYNCHRO-TO-DIGITAL CONVERTER
   - C. BOTTOM SHELF POWER SUPPLIES
5. COMPUTER RACK
   - A. TOP SHELF MINI COMPUTER PDP 11/20
   - B. MIDDLE SHELF COMPUTER EXTENDER MOUNTING BOX
   - C. BOTTOM SHELF POWER SUPPLIES
6. MISCELLANEOUS EQUIPMENT RACK
   - A. TOP SHELF HIGH SPEED PUNCH/READ
   - B. MIDDLE SHELF ANALOG TO DIGITAL CONVERTER READER UNIT
   - C. BOTTOM SHELF PULSE GENERATOR
7. MISCELLANEOUS EQUIPMENT RACK
   - A. TOP SHELF MODE DECODER (TRANSPONDER 2 EACH)
   - B. MIDDLE SHELF MODE 4 DECODE LOGIC EQUIPMENT
   - C. BOTTOM SHELF POWER SUPPLIES
8. ASR 33 TELETYPE INPUT/OUTPUT DEVICE
9. TU 10 9 CHANNEL MAGNETIC TAPE TRANSPORT UNIT WITH TM-11 TAPE CONTROL UNIT
10. TU 10 7 CHANNEL MAGNETIC TAPE TRANSPORT UNIT
11. TACAN RACK
    - A. TOP SHELF 2 EACH ARN 21 TACAN UNITS
    - B. MIDDLE SHELF 2 EACH ARN [illegible] TACAN UNITS
    - C. BOTTOM SHELF SPARE
12. SPARE RACK
    - A. TOP SHELF
    - B. MIDDLE SHELF
    - C. BOTTOM SHELF

FIGURE 29. EQUIPMENT ARRANGEMENT FOR THE AIRBORNE BEACON INTERFERENCE LOCATOR



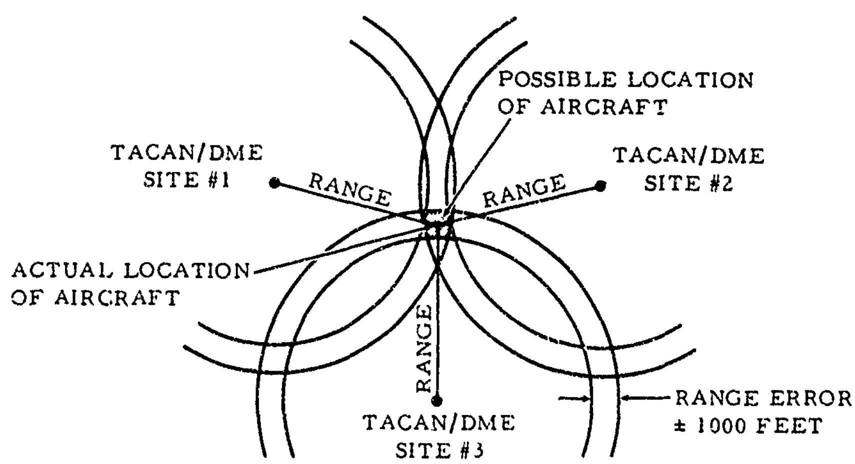
(a)

A SINGLE TACAN/DME STATION USED TO DETERMINE POSITION OF AIRCRAFT (MEASURING RANGE ONLY)



(b 1) (b 2)

TWO TACAN/DME STATIONS USED TO DETERMINE POSITION OF AIRCRAFT (MEASURING RANGE ONLY)



(c)

FIGURE 30. THREE TACAN/DME STATIONS USED TO DETERMINE POSITION OF AIRCRAFT (MEASURING RANGE ONLY)

computations. The only manner in which the latitude and longitude of a search-lighting site could be determined would be to fly toward the site, along the antenna beam.

ASR-7 Stagger Problem.

At the present time, a few ASR-7 Sites are being installed in the field. These radars are equipped with staggered PRF to eliminate radar blind spots (Figure 31). Since the PRF of the radar is staggered over six different periods, the PRF of the racar beacon must also be staggered. At the present time, there is only one stagger rate planned for ASR-7 radars and radar beacons. If more than one ASR-7 radar beacon interrogates an aircraft at one time, synchronous fruit could result from such interrogations.

The contractor that designed and is building the ASR-7 has no definite plans for changing the stagger rate of the ASR-7 radar at this time. A representative of the contractor (Texas Instruments), that I spoke to stated that if a change in the stagger rate is required at some future time, the tuning of the crystal frequency that generates the basic PRF timing might have to be accomplished.

In order for the ABIL System to function acceptably in the future, it must be capable of handling and tracking radar beacon interrogators that utilize non-staggered, as well as, staggered PRFs.

SRDS Flight Inspection Monitor Program.

At the present time, there is an SRDS program to develop an ATCRBS Flight Inspection Monitor. Two types of airborne monitors will be developed under this program. One type will be a simple inexpensive unit intended for implementation on all SAFI aircraft, and it shall be used to automatically and continuously monitor certain critical performance characteristics of the ATCRBS environment. This unit will record data for playback and data reduction, at a later time on the ground, at NAFEC or the Aeronautical Center.

When the simple monitor identifies an area of degraded system performance, a second type of monitor, that will perform the same functions as the ABIL System and will eventually replace the ABIL System, will be employed to obtain additional data on system performance to detect, identify, and locate the faulty interrogators. This more sophisticated system is expected to be installed in August of 1973 on special aircraft that will be used to police the Air Traffic Control Radar Beacon System.

Returning once again to the ABIL System that will be built at NAFEC, the other day we inserted data into the system for the first time to see how well the computer could determine the location of an interrogator. The computer was expected to output the latitude and longitude of the interrogator--but instead of doing this, the computer printed out the telephone number of "dial-a-prayer."

TRIGGER AND COUNTDOWN PARAMETERS

RADAR PRT'S	1 833	2 853	3 893	4 953	5 1053	6 1403	—	—
RADAR TRIGGER SEQUENCE	4 953	2 853	5 1053	1 833	6 1403	3 893	—	—
BEACON COUNT-DOWN SEQUENCE	(2)	(2)	(3)	(2)	(2)	(2)	(3)	(2)

ALL TIMES IN µSEC

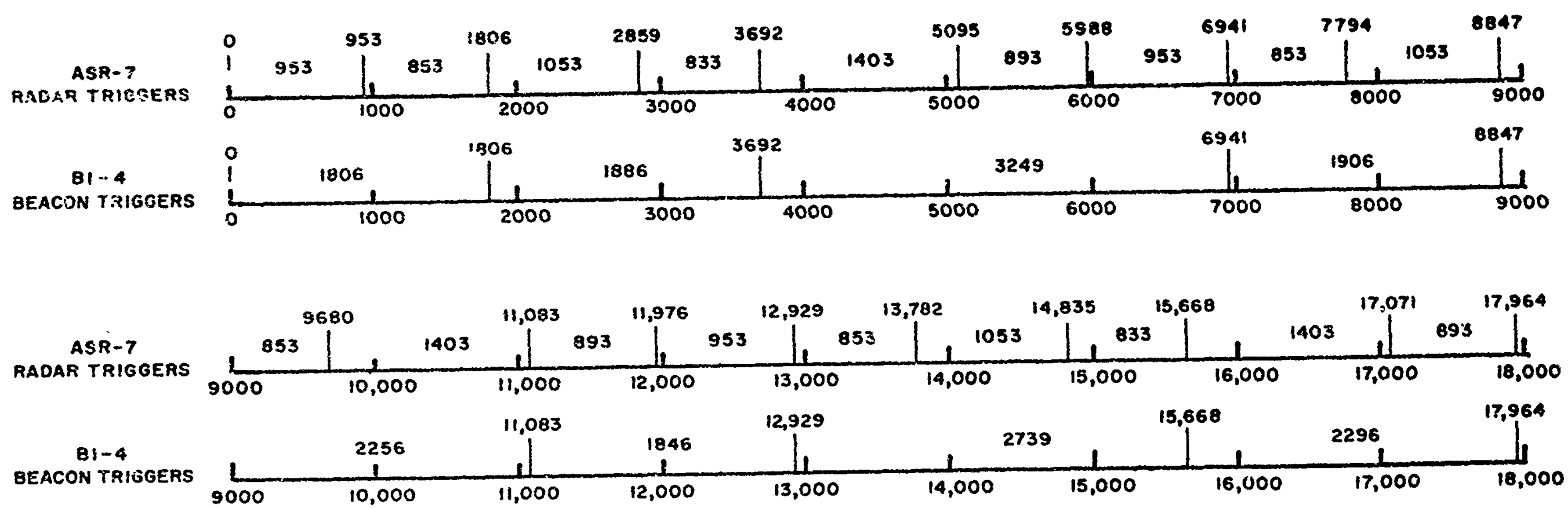


FIGURE 31. STAGGERED PRF ASR-7/ATCBI-4 TRIGGER SEQUENCE

So you can see we still have a bit more work to do. Seriously though, the ABIL System is scheduled to be ready for flight testing in August of this year and we will be looking forward to investigating some of your field problems.

PROPER ALIGNMENT OF BEACON DEFRUITERS

By E. Henry Bowen, EA-421 (14)

The part of my presentation was listed as "Proper Alignment Of Beacon Defruiters." It's not so much that I am going to expound on how to align a defruiter, but it's just three major areas that I've run across in my travels, travelling from one radar site to the next.

Most of the information that I received, or knowledge that I gained about the defruiters was after working in the field for about six years I finally got a chance to go to beacon school, and I gained a good bit of knowledge from it.

Non-Intentional Misalignment Problem.

The objective that I want to try to accomplish is to highlight some of the things in the defruiter alignment that would effect the efficiency of the equipment, and point out a non-intentional misalignment to specs set up in the main opera by some order issued by the various regions.

My first experience in this type of problem came about one day when some controller called me at the Kennedy site and told me that the radar looked like---------, and I got very angry. I jumped into the G-car and drove up to the tower and I went storming up to the IFR room, and I grabbed ahold of the guy, and he and I used to be stationed up in the Navy together, and I told him to define.

I was so angry that he took me over to the scope, and he showed me something that surprised me. Here we had two slashes on an aircraft say 10 miles, and as this aircraft came in towards the station, he'd lose one slash, both slashes, second slash would come back, and as this guy was coming in in-range - the target they could say was broken targets. The target would deteriorate down to nothing, and gradually disappear, and come back again.

It didn't look like what he said it did, but I went back out to the site, and tried to see if I could reproduce what he showed me. Well back in the old days, as my buddy Chuck Will, and some of the older guys that have been in the field years ago know, we didn't have all these fancy scopes, and all of these fancy pictures we get from the manufacturer. We used to go around and draw the wave shapes - what we thought they looked like when the gear was working.

Drawing Wave Shapes.

So I went from test point to test point, to cards involved in this particular problem, and drew the wave shapes. Then I took and set up the beacon test set as if I was going to go through the sensitivity time control alignment.

Now for the air traffic types, all this does is allow me to run a pulse from 60 miles to zero. I put the pulse in, took it out of saturation and looked at the test point that we used on the beacon storage tube defruiter, to show me what was coming off of the storage tube, because at that time I had no idea of how to tell whether those tubes were bad, and a lot of people still don't know, because it's the only vacumn tube in the entire beacon storage tube defruiter, and, I may add, that the majority of the tubes that we have been receiving in the field have been dated back sometimes area 1958 on up - old Army and Air Force surplus stuff, and it was very rare if we saw a tube that was less than two years old.

After all these tests were proven out, I believe Trevose site and also Kennedy site tried to delete the old units maintenance log, for which anyone could call up and say "When was the last time you changed the maggy and how many hours was on it," and a guy could pull the book out and he could tell. But they went back to the old procedure of using a unit maintenance log, and those tubes lasted from five minutes, two weeks, to a maximum of 90 days.

The whole thing now was - how could you check weekly to tell whether these tubes are going to go bad to offset the complaints of missing targets and broken targets, when you couldn't really prove anything was wrong.

Kennedy Fix.

But what happened to me on the Kennedy system was test point B. Those targets varied in amplitude all the way across the storage area into zero range, and the dips - some of those pulses actually dropped out. The framing pulses disappeared, and then the A-1, and so forth all the way through to the second group. One digit would drop out and the guy no longer would be able to decode this target. He would wind up with his one slash.

The missing brackets would explain the reason why he'd lose either the first or second double slash target on his scope. And after working at Kennedy and Washington International, when these guys have got traffic on final, or they're working a holding pattern and targets start becoming eratic, I can see why these guys get upset, experiencing the difference between radar separation and non-radar separation all of a sudden.

This particular test as I have mentioned showed me that there was something wrong. This tube - maybe its burned, having burned spots or dead spots on it. So I replaced it. No disrespect to Oklahoma City or the manufacturer, but we never had any wave shapes to show what that test point three and seven should have looked like, so when I put it in, it was very weak. I saw this gate was positive.

Defruiter Balance.

Now point A is the point where the baseline balance on the defruiter is actually supposed to be adjusted. And I found in my travels that we were trying to adjust this gate to negative, and of course, later on the defruiter started suffering because you couldn't get your video out of it.

After I replaced the storage tubes and went through the regular focus and astigmatism adjustment, low and behold this is what I saw------ a negative gate.

I showed this to my section chief and we started watching and observing, and we got to the point where we couldn't maintain proper MDS or proper defruiting effeciency. We found that after the tube was placed in, and the gate looked like this, we would get the threshold set down and drag all the garbage off the scope. Then over a period of time this gate, would eventually start going more and more towards the baseline, then it would start going positive.

I have seen one defruiter malfunction to the point where this gate was so high in amplitude that when it was processed through the defruiter circuits up to the comparison point where they have a series AN gate, this was a positive gate. So every time the tube would write and the read off of this thing, this positive gate would show up over there and all the garbage came out the same time, and they had either no defruiting, or no output. They were missing video every other rep rate, and there would be a complaint of weak video, or something would happen with the adjustment and let all the interference come through every other rep rate.

Replacing Beacon Storage Tube.

So, as I've been doing my travels as the regional EMCS'er, and I've been going into the various sites, and asking the guys: "When is the last time you changed your storage tubes in your defruiter? How're the interference problems?"

I've been sent out on interference problems and I got no further than the defruiter. Some of the people at some of the sites, one of them way down South, I asked how many tubes they changed, he stuck his chest out and said "Well, I haven't changed a tube in three years. I looked at those gates, we looked at the output, and we changed those tubes, and he was a lot happier when I left, but I was a little upset because he only had two spares.

At the Kennedy ARTS site and some of the other ARTS sites, that I've been to, they carry as many as 10 to 15 spares. The reason we carry that many is that the ones that come out of the box were so dog-gone old, that they wouldn't work when you first put them in.

Wrong Adjustment.

Also, a funny thing happens when they check out a defruiter on a test, when they do the MDS.

Say the man does know about checking the defruiter out, and he adjusts the R 45 21 in the back. They call this a delay video threshold level which controls the amount of fruit more or less that comes out of the defruiter, how efficient the defruiter is going to operate. So in the actual test mode the man will adjust this thing according to the book, and the book warns him that this threshold level will eliminate a lot of the disturbance at test point 44 4505.

He'll go ahead and adjust this thing real good, but they call it a threshold gate, and nobody bothered to tell us that the video that was being stored was never actually presented on any CRT anywhere, because this video was turned into an acceptance gate that will allow a video that's synchronous with it to come out in the defruiter. So he would make adjustments on this thing to where he had an optimium setting and he'd go and say well I'm ready, call the center, call the tower and he'd change his channels.

Again he didn't know what to look for when he put it on, not realizing that every other rep rate was a different tube. And this is one of the things that was observed.

Take a particular saturated target. The signal that I'm putting in is just barely out of saturation from the front end of the receiver. But on every other rep rate this target is below saturation. Sometimes way below. Sometimes its missing. Unless the man knows to stay in the delayed mode in the 545, and set it up so that he can see every other rep rate, he won't realize this, then he runs the MDS to the side and when he made his local MDS, he had a figure of 91, and then when he sent it down to the units he got 89's. He got upset, he was out of specs. What's the natural thing to do? He knew that he dragged the threshold level down too far so he went behind the defruiter, brought up the threshold level or he actually widened his acceptance gate to get both videos up to saturation, and he wound up with interference on the PPI and he didn't know why.

This is an in house fix on some of our interference problems that we've gotten into with the RFI program that we've had in the Eastern Region, where I've been traveling from site to site discussing these various problems with the people. I intend to write a report on this so that it can be disseminated into the field, so that the other fellows can tell when these storage tubes are going bad before the MLO calls him and tells him that he's got bad video.

Summary.

To briefly summarize the activities that we have been envolved with; We've gotten requests from engineering, and from various sites to take a look at their SLS levels and their main beam levels.

I have recieved most of the information that I have from John Kemper, and I have a special scope in my van, whereby I can freeze the beacon pulses as they come of the antenna and photograph them and get a relative level, and then compare it to a photograph SLS level, to tell whether or not the man has his ISLS on his proper levels or, on the regular SLS, whether he has the proper dB difference between the omni, and the direct.

Ramp Test Problem.

We've been tracking down ramp testers, from some of the air lines, and I would like to mention the fact that Pan Am and United Air Lines in the Eastern Region have been the most cooperative air lines I've ever seen. They call me on the phone when they get a ramp tester out of calibration to check it out. Something like that is greatly appreciated.

I went down to Dulles Airport with the van, because I was too scared to try this little experiment at Washington National, and I found a very surprising thing. When the aircraft landed at the airport he didn't bother to shut his transponder off. So I drove around the various aircraft. You could sit in front of one, listen to 1090, pick up the replies coming out of his transponder which almost burns the front end off the meter, and hear different radars interrogating him while he's on the ground.

We issued a letter and requested certain changes be made. The one change I requested I didn't hear anything about.

The A manual suggests that the pilot should shut his transponder down when he's taxiing, and turn it on just prior to take off. I would like that word "should" changed to "shall," so he'll do it.

Phantom Transponders.

Some of the other things I've run across with the van is that manufacturers with military contracts were working airports services with ramp testers mounted in vans driving all over the airport checking out the various units, and they don't use the procedure where they jack in, they just radiate 1030 all over Kennedy Airport. These are the mobile ramp tests that some of the air lines have been using. And then the ones with the military contracts have ramp testers that they use and they don't bother to get a license for it because they figure its an Air Force contract, and we get a big surprise one day.

One particular company was building a beacon transponder radiating 1500 watts, eight hours a day, 5 days a week, and his antenna was less than 300 feet from the ASR antenna at Baltimore. They swore they were not radiating. I checked it out with the van using 100 dB attenuation and it almost burned the meter out. Finally the guy says he's got an Air Force contract and shuts it off, and the thing went away. I was wondering why was he radiating if nobody was in the building. This really messes it up.

We have another problem where I made superimposed spectrums of two different radars simultaneously, because one of our sites could only operate with the integrator on, and every time the integrator failed they'd NOTAM the radar. They found out that it was a military radar that was doing it, and they were very cooperative, and went to the great expense of putting in totable maggies. They went up one end of the van and we went up the other.

There was a private contractor acting in the same area. We shut him down, because there was no reason for him to operating when he didn't need to be.

One more thing - Mr. Spingler was talking about flying around by Trevose, and I found a radar down there, belonging to the Marine Corps that had a spectrum that went from 1200 with one of his major tubes sitting on 10 percent. We were wondering why we were getting so much garbage in the scope, and we had a lot of cooperation from them. They do shut down.

I would really like to see the efforts in regions coordinated so that duplications of efforts aren't being made to do certain work. And also those of us who are floundering about on the ground can assist the others, especially in any aircraft. While I'm on the ground I can talk to him and help him out.

TWO CHECKS ON THE BEACON DEFRUITER STORAGE TUBE

By E. Henry Bowen, EA-241 (14)

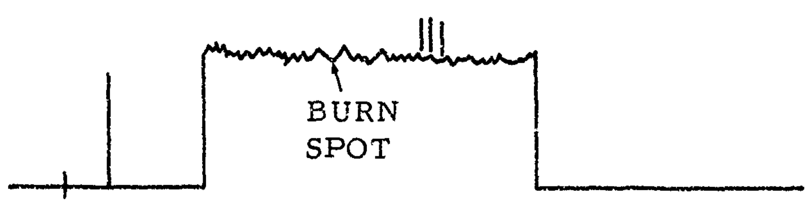
FIRST CHECK

TP-4503 and TP-4510 on the Amplifier Driver Card are the test points used when making focus, astigmatism adjustments and baseline balance. View one of these test points; TP-3 upper storage tube, TP-10 lower tube. Read-video from a normal tube should be riding on a negative gate.

TP3, AND 10, NORMAL WAVE SHAPE (NEGATIVE)

When tube starts to deteriorate, the gate will begin to approach the baseline and then go positive. When this gate has gone positive, slight adjustments are usually made to the delayed video threshold to compensate for weak video. When sensitivity and interference become a problem and check at TP-3 and 10 has gone positive, tube should be replaced.

TP3, AND 10, NORMAL WAVE SHAPE (POSITIVE)



SECOND CHECK

An additional check can be made for storage tube failure. At TP-4504 and TP-45, respectively, Delayed Threshold Adjustments may be checked. These test points provide one more stage of amplification, and are the points where the threshold voltage is applied.

The DC level at TP-4504 and TP-4511 should be between +0.5 and 1.0 volts or positive (+) enough to eliminate spurious signals from the storage tube and provide a proper output. If the video observed at this point is deteriorated, adjust Delayed Threshold until video is stronger or equal

amplitude. However, if the storage tube or tubes have deteriorated to an unuseable stage, it will not be possible to obtain a strong signal at TP-4504 or TP-4511 without sacrificing defruiter efficiency.

When complaints of fading and missing targets are received, the followint test will verify defruiter operation and/or storage tube quality.

(1) Set up SECRA test set and oscilloscope as you would be STC alignment. Instead of a single pulse, code 77 emergency is recommended.

(2) View RX output and set pulses to a point well out of saturation.

(3) Observe TP-3 or 10, depending on which tube is to be checked.

(4) Delay pulses out to max range and slowly decrease delay while observing pulses. Pulses should remain at or near the same amplitude as pulses approach the beginning of the spiral sweep. This represents a normal condition.

Adjust the delayed video threshold very carefully, as this will affect defruiter efficiency. Refer to the defruiter instruction book, Section 5.9, Step "G."

However, if tube has deteriorated and has burnt spots, the video will have a severe roller coaster effect and amplitude variations which are almost equal to the residue picked up from the tube. Also, the pulses will pop out and return as they are slowly moved. (This would explain random loss of a discrete target and varying target strength as they move along their route.) If this occurs, tube should be replaced.

It is recommended that these checks be accomplished on a weekly basis while the gate is negative. When the gate becomes positive, monitor it on a daily basis until the failure becomes imminent and then change the storage tube or tubes. Numerous SECRA problems have resolved by corrective maintenance to Storage Tube Defruiters. It has been found that after all adjustments have been optimized in accordance with Tube Adjustment, that difficulties existed that could only be resolved by replacement of the storage tube. If the storage tube is bad, adjustment will only degrade the defruited operation, but never improve it.

SUMMARY OF DISCUSSION ON ELECTROMAGNETIC INTERFERENCE

By Gerald J. Markey, RD-525 (15)

The FAA in 1969 became the right arm of the executive office of the President for regulation and control of the 1030 and 1090 environment. We are the focal point of the government agencies and are responsible for coordination and new assignments which includes; PRR, power, hours of operation, and operation use.

In order to carry out this responsibility we are required to have a complete knowledge of the 1030, 1090 environment. Currently each region is validating our national list to ascertain who uses these frequencies and update this list.

Knowledge of the 1030 environment is necessary for radar interference analysis to clear current RFI problems, and for planning and selection of new radar facilities. Frequency Management, FAA, is the focal point for reporting the resolution of RFI problems relating to secondary radar beacon.

Vans.

Today, there are four van's, monitoring vans, in four regions. These frequency monitoring vans are available for chasing down interference problems. Two of our regions, Eastern and Western, currently are going ahead with additional portable RFI capability, and we in Frequency Management Division in Washington are insisting that all regions have this capability. Today, if the Southern Region, or Rocky Mountain Region, has a problem, I'm sure that we could get them a frequency van from the existing regions that have them to give them a hand under emergency conditions.

We recommend that 1030 spectrum plots, and antenna radiation patterns be taken during site surveys by the monitoring vans, and prior to facility commissioning. These spectrum antenna patterns should be incorporated into the facility commissioning documentation. We believe that these spectrum plots and antenna patterns will help analyse P_1-P_2 power relationships, timing, and ascertain whether the SLS is indeed working. The P_1 and P_2 pulses can be checked up to a point inside the building, but it is also very nice to know what is in the air.

Aircraft.

During the seminar George Spingler at NAFEC, described a 1030 policing aircraft. This airborne detector is of great assistance in tracking down illegal bootleggers, that use the 1030 spectrum. The agency must establish a quick reaction capability for the use of this aircraft. This aircraft is booked up 2 or 3 years down the line, but Frequency Management can help you today with the vans.

The monitoring van has a 1090 receiver, and a directional antenna, and with a triggered A scope it can analyse a PRF interference problem. They have difficulty tracing down the guilty interrogator itself in congested areas because they get swamped out by their own P_2 pulses at 1030, but they can analyse and say the interference is a PRF of 270 or 260, and go back to our list of interrogators to find which is the problem. At least we can determine what the PRF of that interference is.

Worst Problem.

During the past 5 years it has been our experience that the majority of harmful interferences have been caused by unregistered interrogators, or registered interrogators that are not operating under their licensed parameters; a change in PRF, power, or use. A ramp tester moved from New York to Miami was fine at New York, but it had a rep-rate that interferred at Miami. Omni ramp testers, which are high-powered, have been a problem. AFCS has worked up a modification for these UPX-7's to lessen ramp tester interference. Non-government contractors, and intermitant RFI, from airborne and shipborn interrogators, have also been a problem.

Pulse Repetition Rate (PRR) has been the key to many of these problems. Direct synchronous PRR's monitor related 360, 720, which are ratio related, 2/3's the least common denominator type, have been found to be an interferer in the last few months.

Unstable, drifting PRR's mean blocking oscillators; need to establish a systems trigger - no external synch can be a problem.

Search-lighting antennas with high rep-rates cause interference also. Manufacturers making certain tests cause these.

Rotating antenna's with poor radiation patterns, and no SLS capability, can let interference through. Military authorities have a new modification available for military facilities which require a power reduction that is a must for those without SLS. AT Santa Ana in L.A. the power reduction alone was enough to eliminate a big interference problem that was caused from side lobes.

Defruiters need to be checked out and aligned. The storage tube life of a defruiter can vary from 1 day to 90 days. We recommend a weekly check on these defruiters. Degradation of the storage tube can cause 1090 interference by itself. This may cause a technician to unwittedly misadjust the defruiter threshold level in order to maintain an overall system sensitivity. This misadjustment creates synchronous fruit and saturation.

If you have a problem contact your Regional Frequency Manager. Make him work for you. Call me on any interference problem. Call us when it first occurs not when it starts breaking your back.

FALSE TARGETS WORKSHOP

PROBLEMS OF FALSE TARGETS AND A NEW ANTENNA TO HELP FIX THEM

by Martin Natchipolsky, RD-242 (16)

Siting Problem.

The problem of siting the L-band Beacon Interrogator Antenna differs from that of siting a primary radar operating at the same frequency because of the different effects of reflections in the azimuthal plane. Coverage problems for primary and secondary radar siting are essentially the same in both cases because:

1. L-band frequencies require line-of-sight clearances for complete coverage. (The use of profile photographs calibrated in degrees in both the horizontal and vertical planes provides an adequate indication of any interference from surrounding terrain or obstancles.) The antenna must be sufficiently high to prevent low-angle shielding within the desired coverage.

2. Vertical lobing from ground reflections is prevalent at L-band frequencies. Flat, smooth ground surfaces, such as runways and taxiways, may cause vertical lobing with nulls being reported as deep as 16 dB and greater. Antenna height again has advantages. Height helps by spreading out ground-reflection energy and presenting a rougher surface for reflections. A higher number of nulls with narrow spacings between lobes also occurs.

Therefore, a high site with a clear horizon and rough ground surroundings is optimum for the beacon from a coverage standpoint. Because the frequency separation between the interrogation and reply paths eliminates echo returns, ground clutter is not a problem. This factor of ground clutter, however, limits the desirability of a high site in primary radars.

Reflection Problem.

The main problem of beacon interrogator siting is therefore the problem of reflections in the azimuthal plane. Exact predictions of the severity of possible reflections from ground objects are not possible, since few reflecting surfaces are ideal lossless flat-plate areas, and the amount of divergence and absorption will vary considerable from object to object. Since it is almost impossible to eliminate all structures in the vicinity of the ground unit, some reflecting surfaces may be expected to contribute false reflection targets to the beacon display. Therefore, it should be desirable to outline several general rules to minimize the seriousness of the existing reflections.

1. Wherever possible, site the ground antenna as far from existing structures as possible. Interrogation can occur as far out as 100 miles when reflected off a lossless 20 x 40 foot flat-plate obstacle at a range of one mile from the antenna. (Figure 32).

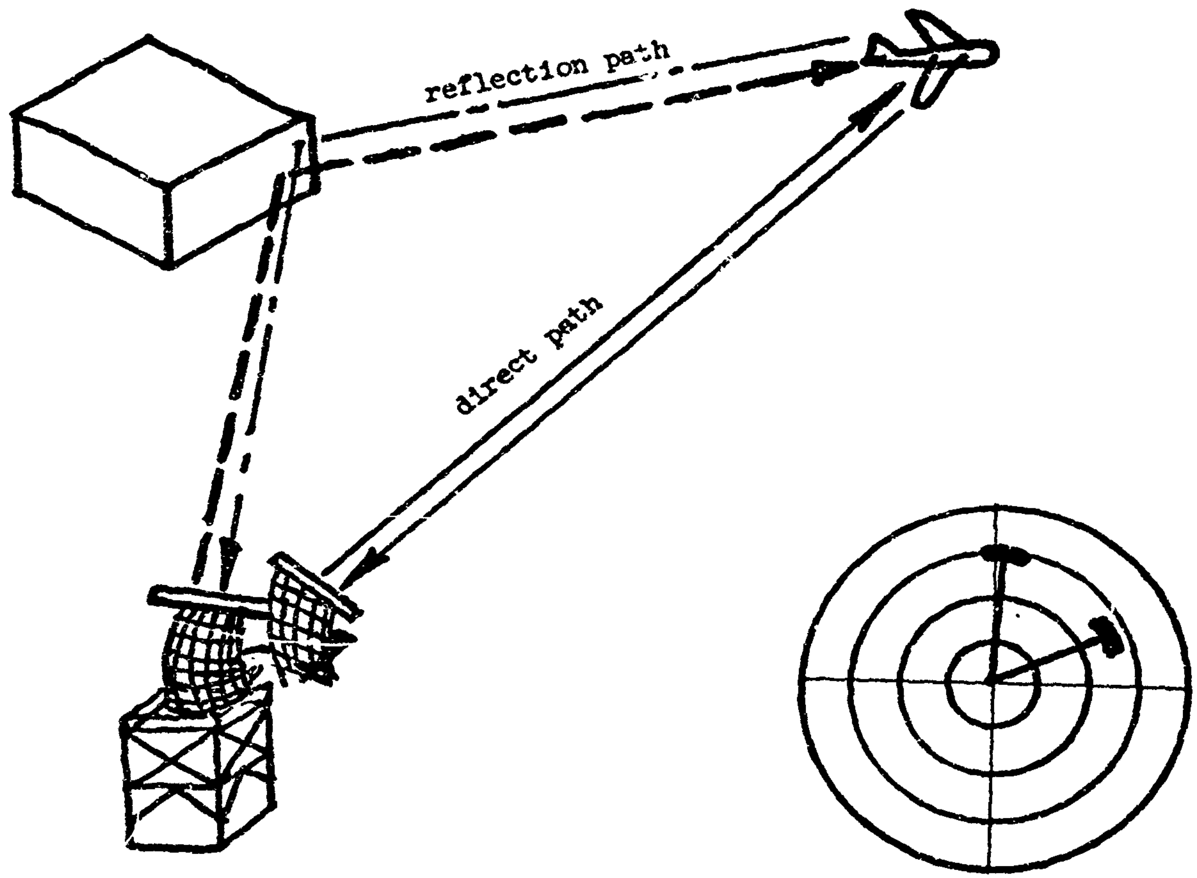


FIGURE 32. EXAMPLES OF FALSE TARGETS CAUSED BY REFLECTION

Although a 20 x 40 foot area is not much larger than the side of a two-story house, divergence from irregularities and absorption from other than metal surfaces reduce the reflection efficiency and maximum reflected interrogation range.

2. Where step 1 is not possible, and large reflecting surfaces are presented to the interrogation radiation at zero degrees elevation, or at slight positive angles, move the antenna to an on-field site directly over the worst reflecting surface (such as the roof of a hangar, terminal building, etc.). Vertical surfaces at more negative angles below the horizon, though still in a strong radiation area, tend to reflect the energy down into the ground and back toward the antenna. This further attenuates any reflected signals.

3. If several sites are available and it is not possible to eliminate reflections using steps 1 and 2 at any location, the most desirable site would present reflections or false targets in an area or azimuth quadrant where traffic is not usually controlled. False targets are generated in the same azimuth as the reflecting surface. If possible, this azimuth should be oriented away from controlled airways, approach paths, or holding stacks. Secondary to this consideration is the amount of traffic in the area from which the reflecting surface derives its replies. This azimuth can be approximately ascertained from the optical reflection angles presented to the beacon antenna radiation by the reflecting object. An area with no traffic will reflect no false targets and hence will not contribute to the problem.

A theoretical analysis of reflections from obstructions at L-band was made for several flat-plate reflecting surfaces of varying size. An example of this type of calculation is given below for a 20-foot by 40-foot flat-plate reflecting surface.

A P cos θ curve is plotted for the radiated energy in the vertical plane. From this, the percentage of incident energy is computed from the angle subtended by the height of the obstacle at varying ranges from the interrogator site. A planimeter measurement gives the ratio of the incident energy to the total energy in the vertical plane. This same type of measurement is made to calculate the energy in the main lobe in the azimuth plane (side-lobe reflection paths have been neglected in this computation). The amount of power on the surface is therefore the vertical ratio times the azimuth ratio times the transmitted power. This total incident power is computed for various ranges of the obstacle (Figure 33).

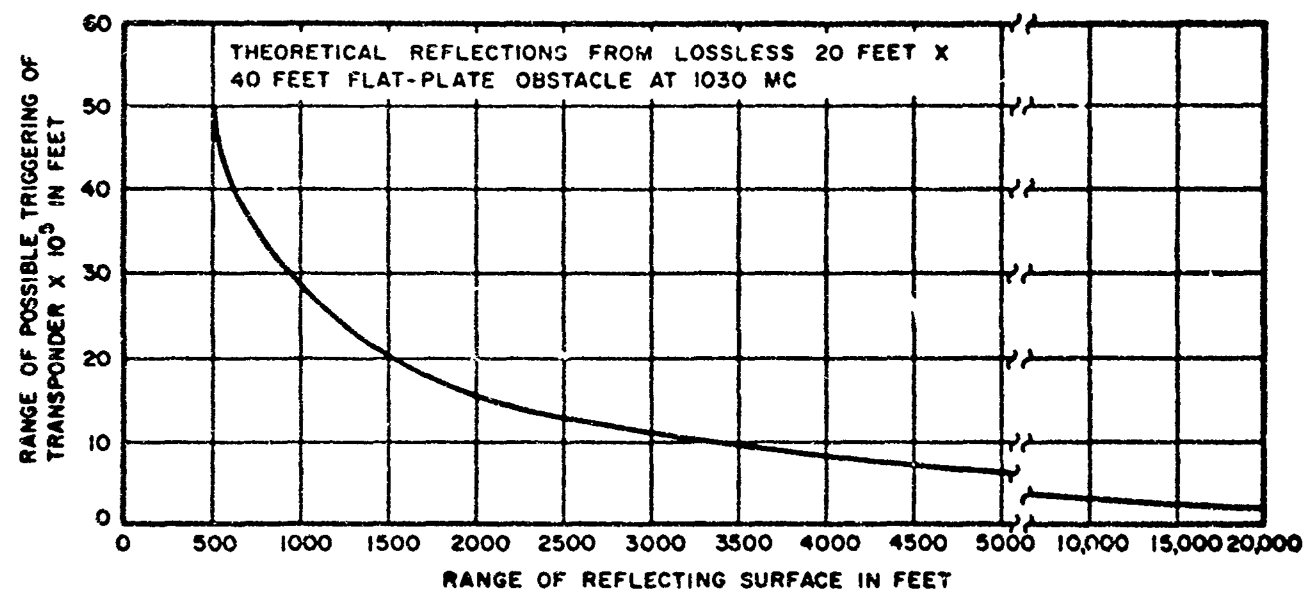


FIGURE 33. PLOT OF THEORETICAL REFLECTION RANGE

To compute the range of interrogation for the reflected energy, we use the standard range equation

$$R = \sqrt{\frac{G_r G_t \lambda^2 P_t}{(4\pi)^2 P_R}}$$

where

P_t = incident power on obstacle at varying ranges
P_R = triggering level of transponder (assumed at 10^{-10} watt)
λ = 0.291 meter
G_r = unity

$$G_t = \frac{25{,}000}{\theta_1 \theta_2} \text{ where } \theta_1 = \frac{51.5\lambda \text{ (meters)}}{D \text{ (feet)}} \text{ (vertical plane)}$$

$$\theta_2 = \frac{84\lambda \text{ (meters)}}{D \text{ (feet)}} \text{ (azimuth plane)}$$

R = range of interrogation in feet

A plot is shown above of the theoretical range of interrogation from a lossless flat-plate reflecting surface measuring 20 feet by 40 feet. The extreme range of possible interrogations caused by reflections indicates the theoretical possibility of gain in a reflection path. Few obstacles, however, have the properties assumed for the theoretical example, and scattering and loss in the reflecting surface reduce this extreme range by an amount that is dependent on the properties of each surface.

Since airports in general do not present clean site advantages for beacon interrogator installations, some reflections may be expected. It appears hopeful, however, that a by-product of the side-lobe-suppression system will also discriminate against reflection or false-target returns from aircraft within side-lobe interrogation range. An aircraft interrogated by a side lobe will not reply to that interrogation. In addition during the resultant suppression time, the transponder will be desensitized to high-level-reflection interrogations that have been delayed by the longer reflected-energy path.

Improved Side Lobe Suppression (SLS). Improved SLS is a modification of the basic 3-pulse SLS which eliminates false target replies by preventing interrogations by reflected interrogation pulses. Reflection interrogations and the resultant false target replies are much more prevalent than originally predicted. This increase is attributed to the trend toward construction of large buildings, hangars, and fences in the vicinity of the radar transmitter sites. This situation is more common at terminal radar sites than at enroute radar sites. This modification has been installed in practically all FAA ATCRBS facilities.

Reflection Sources at Beacon Sites.

Prior to installation, the proposed beacon sites in the New York area were examined to determine the probable sources of reflections surrounding each site. At the individual radar sites, photographic profiles were taken. From these profiles, and with the aid of plan views of the airport, major possible azimuths of reflection were plotted. This was done to establish the azimuths of reflections from on-the-field obstructions such as hangars, terminal buildings, and towers, and to establish the azimuths of reflections from distant off-the-field obstructions such as gas tanks, buildings, and chimneys. These possible azimuths of reflection were compared with the azimuths of airways and feeding-stack arrangements at each particular airport to assess the possible seriousness of the reflections.

Of all these beacon sites, the LaGuardia Airport ASR site presented the most serious reflection problems, not only because of the number of reflecting surfaces in that area, but also because of the quadrant in which the reflections were located.

A plan view of the LaGuardia ASR beacon site (Figure 34) shows major probable reflection paths, with the location of the airways superimposed over the plan view. The areas shaded with solid lines show the azimuths of on--field reflections, and the areas shaded with dashed lines show the azimuths of off-field reflections. The airways and holding stacks are superimposed over the plan view in heavy black lines. The plot of actual reflection false targets obtained during flight tests shows the close correlation between predicted and actual reflection azimuths.

The Beacon-Interrogator Antenna.

The ATCRBS antenna presently in use has a vertical aperture of only 20 inches. A fan beam is formed to cover a range of elevation angles above the horizon, but, with only the small vertical aperture, angles below the horizon are also strongly illuminated. The resulting ground reflection causes a serious "vertical lobing" or cyclic variation of net radiated field strength as a function of elevation angle. When an aircraft is in one of the minimums between vertical lobes the signal can be so weak that the aircraft becomes a "missed target." An additional problem caused by illumination of the ground is that spurious reflections from nearby buildings cause "false targets."

Another shortcoming of contemporary antennas is the inability to form the desired omnidirectional pattern for the side lobe suppression (SLS) technique employed by the ATC beacon system. The vertical shape of the onmi pattern ideally should match that of the fan-beam pattern, including the vertical-lobing structure caused by ground reflection. In order to do this, the vertical aperture and phase center of the omni radiation should be identical to that of the fan-beam radiation. The separate omni antenna commonly employed cannot meet these requirements,

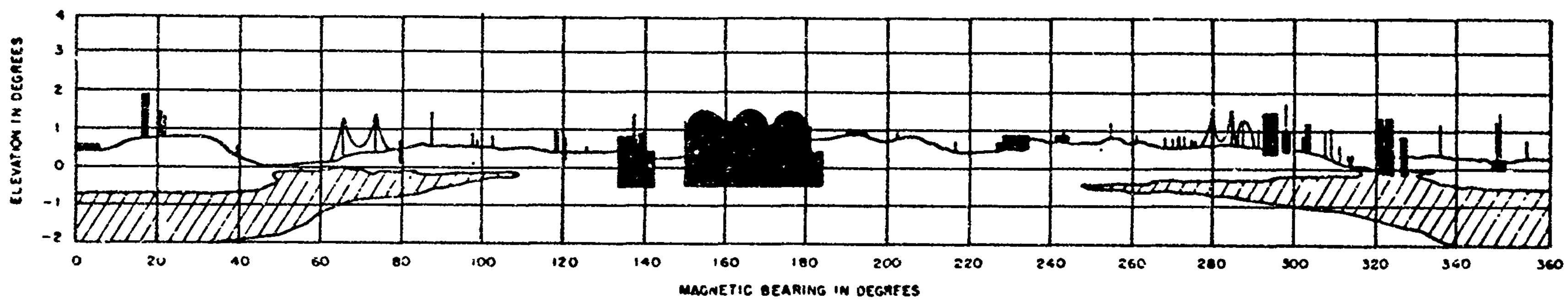


FIGURE 34. AZIMUTH PROFILE OBTAINED AT LA GUARDIA TOWER ASR-ATCRBS

and the imperfect SLS operation that occurs can result in spurious side-lobe responses as well as contribute to missed targets and false targets.

The New Antenna.

The FAA is sponsoring the development of a new beacon antenna, an electronic-scan cylindrical array. Figure 35 (a) and (b) illustrates the new antenna in a typical location under an airport-surveillance-radar (ASR) antenna. The new antenna is stationary and independent of the radar, but its beam of radiation can be electronically scanned around a full circle in synchronism with the radar beam. The electronic scan antenna is a circular-cylindrical array 8 feet high and 40 feet in diameter. The array comprises 224 columns of dipoles; each group of four columns is enclosed in a radome, giving the antenna the corrugated appearance seen in the drawing. The circuits that provide electronic scan in azimuth are contained in a centrally-located enclosure under the antenna.

Radiation Patterns of the New Antenna.

The three basic types of azimuth radiation patterns provided by the new antenna are: (1) the main fan beam about 2.5 degrees wide in azimuth, (2) a monopulse-difference pair of fan beams, and (3) the omni pattern for SLS. All three of the azimuth pattern modes have the same elevation-pattern shape. Most important, this elevation pattern has a sharp cutoff at the horizon. This is made possible by the substantial (8-foot) vertical aperture dimension of the new antenna.

Benefits of the New Antenna.

First, the sharp cutoff of the elevation pattern below the horizon greatly reduces the strength of signals that reflect from the ground and cause vertical lobing. This is expected to result in a major reduction of missed targets.

Second, the new antenna has limited electronic scan in elevation. This permits the azimuth-scanning sharp-cutoff fan beam to "hop over" buildings that are often located near airports. The resulting reduction of spurious reflections will permit a major reduction of false targets.

Third, with the new antenna the omni pattern is radiated from the same aperture that radiates the fan beams, rather than radiating from a separate antenna. This "integral omni" feature of the new antenna ensures that the residual vertical-lobing effect will be the same for the omni and the fan beams. This is important for best operation of the SLS technique, and will eliminate spurious sidelobe responses resulting from vertical-lobing mismatch as well as further reduce missed targets and false targets.

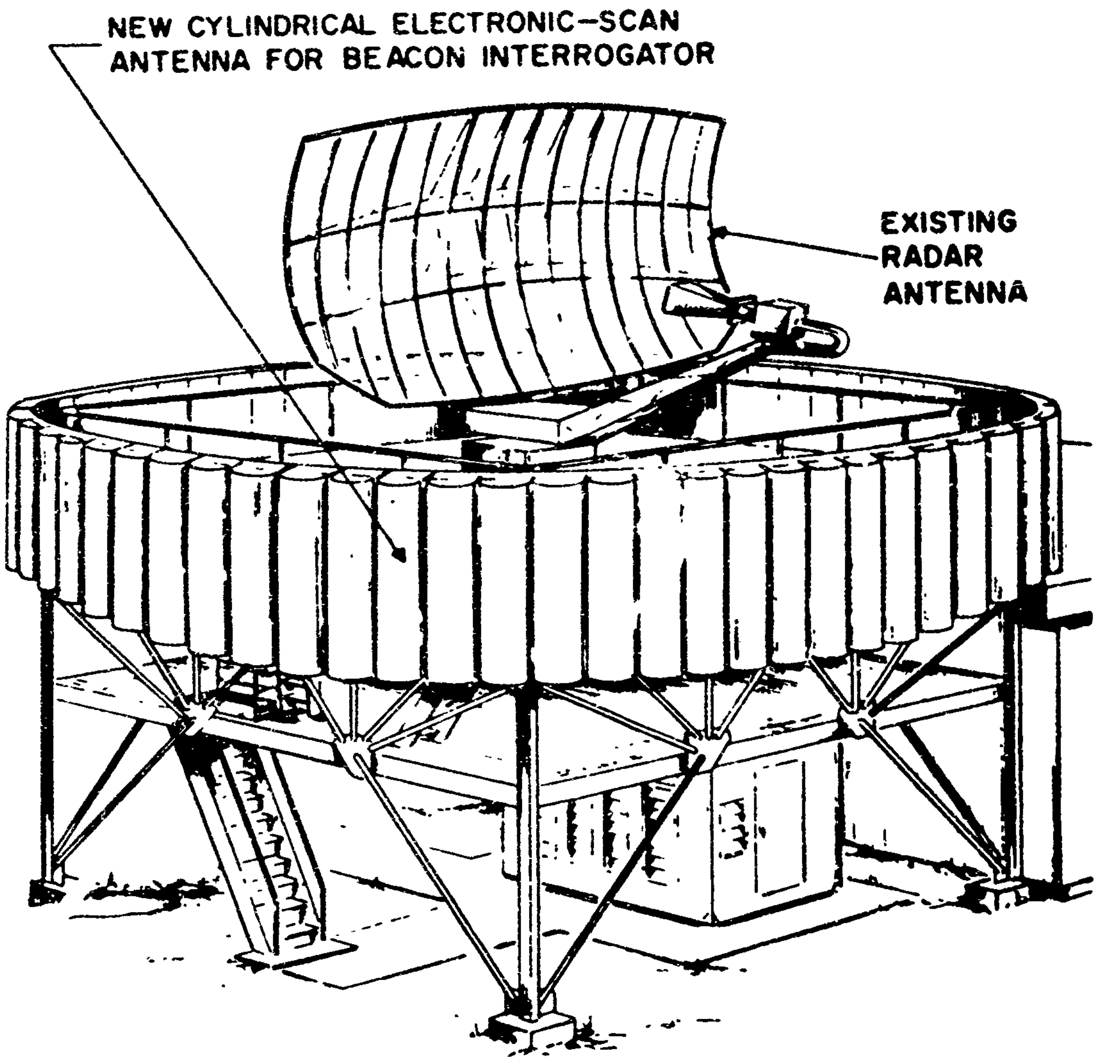


FIGURE 35a. THE NEW CYLINDRICAL ELECTRONIC SCAN ANTENNA

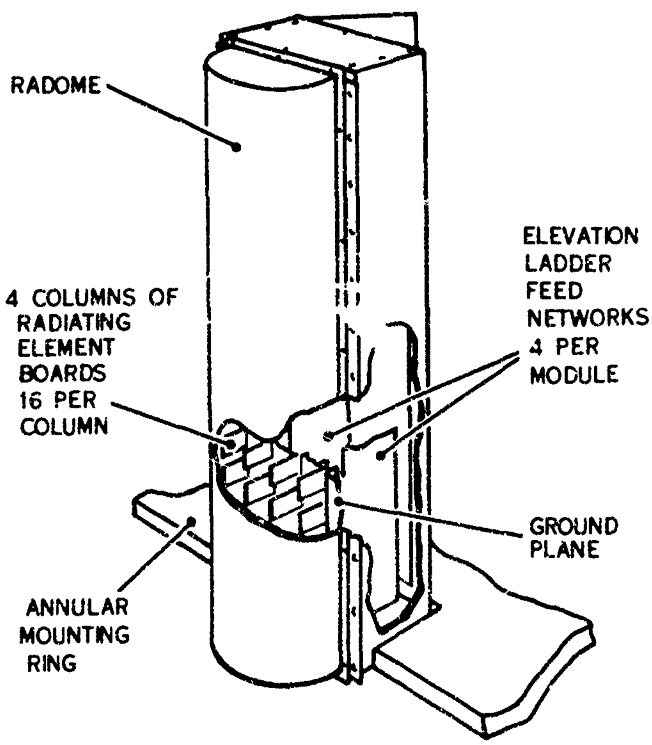


FIGURE 35b. MODULAR CONSTRUCTION OF THE ARRAY

Fourth, the azimuth electronic-scan capability of the new antenna permits an agile-beam mode of beacon-system operation. This will become essential for increased traffic-handling capability in high-density areas, and will be appropriate for use with the new discrete-address beacon system (DABS) that is presently being planned.

Finally, inclusion of a monopulse difference pattern for reception permits the accurate determination of aircraft azimuth angle from a small number of replies, or even from a single reply. This will become most significant with the DABS system that may rely on a single reply for complete information in high-traffic situations.

GUYED RML TOWERS CAN BE A PROBLEM

By Frederick Wong, DC-430 (17)

We operate a joint use, joint maintained FPS-7 long range radar, modified by installation of an ARSR-2 antenna. The beacon antenna is a standard FAA type.

Some time ago, the Air Force asked for permission to install a microwave repeater tower adjacent to the radar tower. They proposed to install a standard 4-fort triangular based 180 ft. tower at a location which we found conformed to the requirements of FAA drawing DRD5109-1. A dispatch was sent to Washington requesting information concerning what detrimental effects were experienced from similar installations. The reply indicated that guyed RML towers are adjacent to most FAA LRR's with no detrimental effects to the radar performance, and that in some isolated cases beacon reflections from RML towers were reported. Also noted was that no detailed data or installation criteria are available.

As a result, a permit was issued under condition that the Air Force would be responsible for correcting coverage derogation, caused by the tower installation (Figure 36).

After the tower was installed at 275° we noticed that all targets on that heading were elongated from a normal 4° - 5° to 18° - 20°, and that the beacon/skin azimuth correlation was skewed left or right depending on whether the real target was left or right of the tower azimuth. This seemed to affect all beacon returns from 20 - 150 miles range at altitudes from 5000 feet up. Screens attached to the tower only resulted in false targets from either azimuths and were therefore removed.

The problem affects two adjacent airways used by both inter island and international carriers. There have been ATC complaints since it affects a climbing/descent zone.

We have asked the Air Force to correct the situation and they in turn have tasked the tower builder in accordance with their contract.

Meanwhile, we suggest that the standard site plot drawings and clear zone requirements be amended to conform with recommendations of NAFEC report 69-36 (Experimentation and Analysis of Siting Criteria), page 75, which touches on the problem of RML tower siting. It would also be beneficial to know what the bare minimum separation requirements between beacon and RML tower could be and the effects in the event that terrain or land acquisition problems require siting RML towers at less than optimum separation (Figure 37).

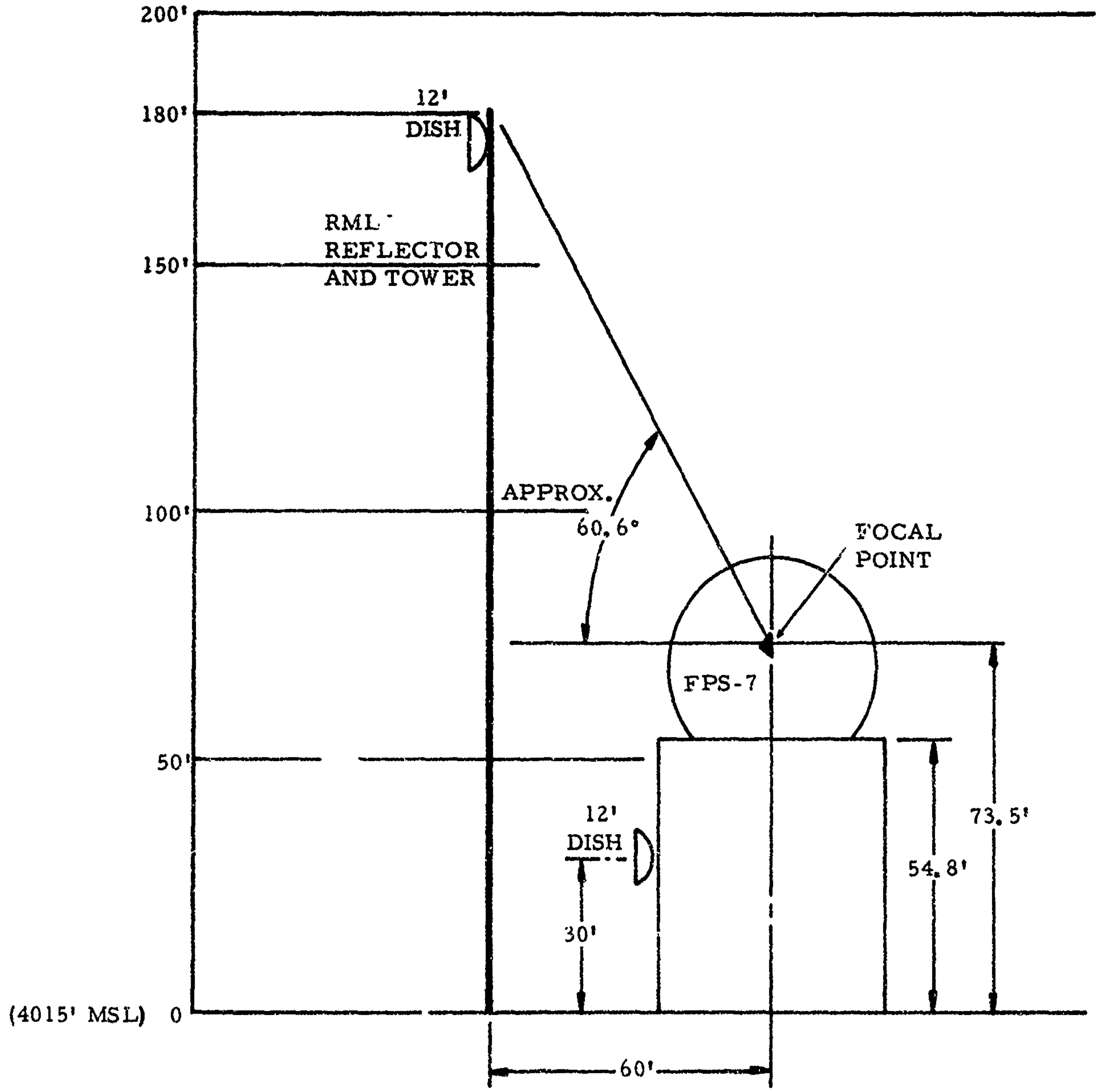


FIGURE 36. HANG RML TOWER ELEVATION

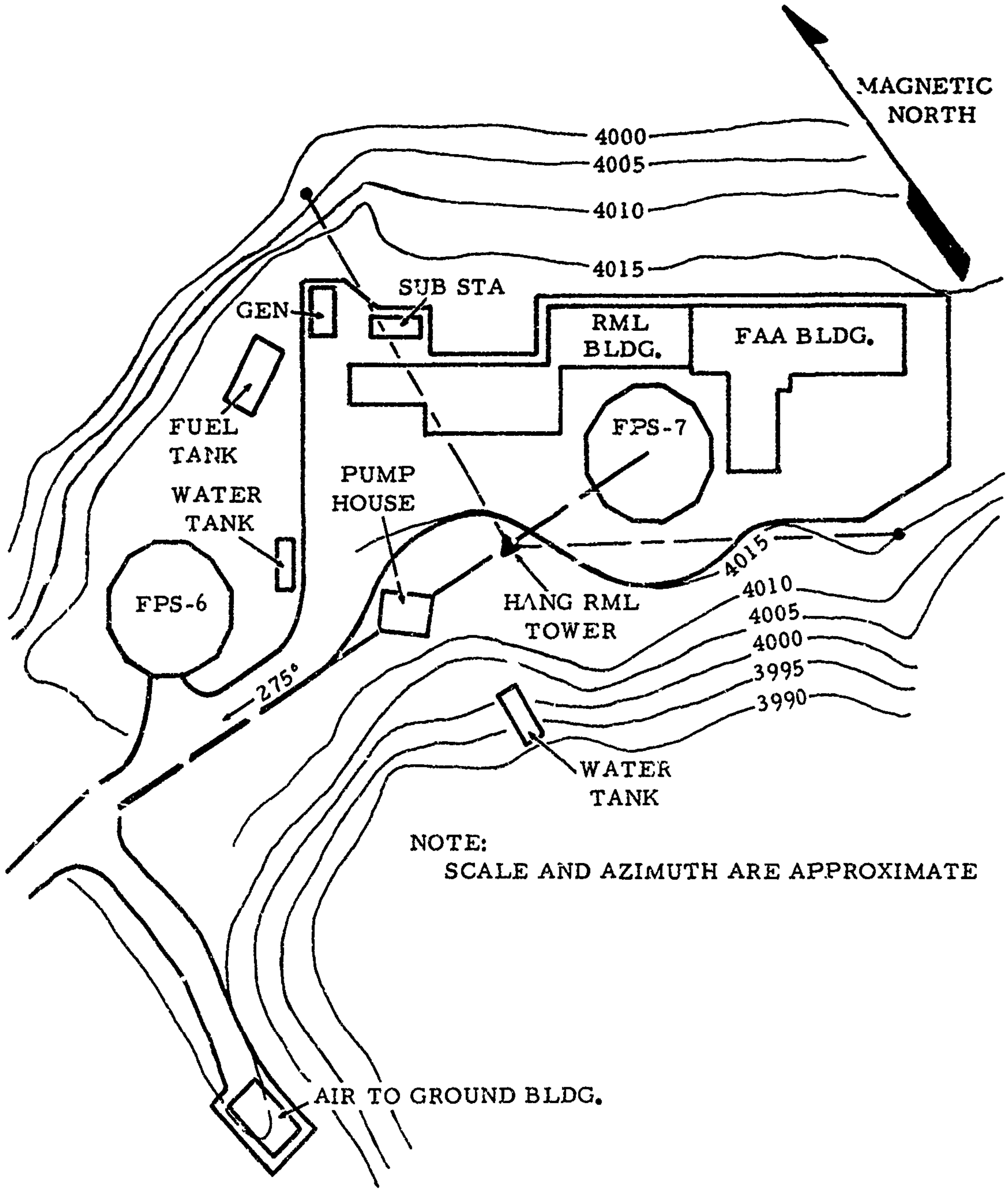


FIGURE 37. MOUNT KAALA SITE PLOT PLAN

FALSE TARGET OPERATIONAL PROBLEMS IN THE JACKSONVILLE NAS SYSTEM

by A. V. Shaw, AFS-22 (18)

Jacksonville Center is presently using radar digitized dat for the control of air traffic in the high altitude structure. Since its initiation, there have been numerous terminations of its use by the controllers because of false targets. The false targets are in such great numbers, and so vividly presented by the DFG, that one cannot descern between the real and the false targets. In reverting back to the broadband system, the controller is able to recognize the real target by using normal radar with the beacon presentation.

Tower Problem.

The problem source for Jacksonville Center radars has been identified by the use of a computer program called DRANDA. While flying through the Jacksonville Center control area, aircraft of opportunity were recorded and analyzed using digitized data. These computer printouts of DRANDA indicated many troubled areas and led to an investigation of siting problems. Three sites were found with RML towers as reflection sources and one of the three had metal communication towers located within 700 feet of the radar antenna. The communication towers are suspected to be the cause of random ghost or false beacon targets.

Quick Computer Printout Fix.

The evaluation of Beacon radiation troubles in the Jacksonville Center's area has uncovered a most effective and economical tool for evaluation of radar sites beacon radiation coverage. Through the process of recording aircraft of opportunity, the four quadrants of a radar sites beacon coverage can be checked. The only personnel directly involved with this operation would be one SE/ASE initiating the necessary coordination.

Aircraft with Mode C capabilities would be selected and requested to transmit a discrete beacon code. The selected aircraft would transverse the Center's coverage area in a matter of minutes requiring very little time of recording. Upon completion of recording, the off-line computer is loaded with a DRANDA program and a reduction printout is available within thirty minutes. This evaluation tool makes it possible to analyze all four Jacksonville Center's radar sites beacon coverage in one days time.

REFLECTED FALSE TARGETS AT LOS ANGELES, CHICAGO, AND TREVOSE
AND SOME FIXES

By George F. Spingler, NA-533 (13)

My topic this morning will cover field problems that have been investigated by NAFEC related to reflected radar beacon replies. I will outline the problem areas in which flight tests were conducted and the solutions that were devised to solve the problems.

The FAA radar beacon system was established to provide the air traffic controller with spatial position data and identity on aircraft under his control. In order to insure optimization of the air traffic control system, the radar beacon system must provide continuous coverage and fidelity of the positional information. At the present time, the radar beacon coverage at some field sites is far from continuous; due to vertical lobing and, wherever reflected radar beacon replies occur, the fidelity of the spatial position data is compromised.

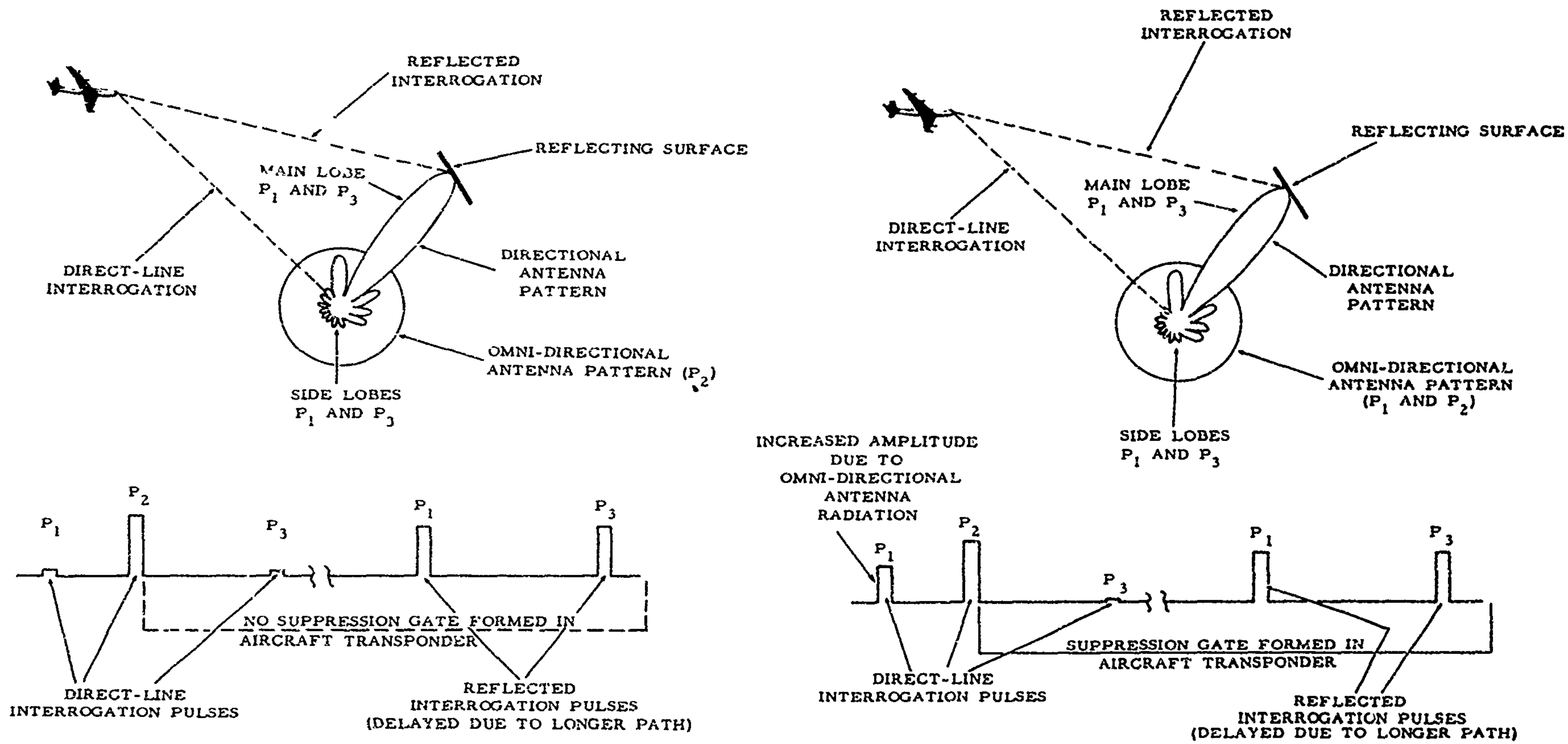
What is a Reflected Target?

The existence of reflected radar beacon replies in the air traffic control system causes the radar beacon reply from an aircraft to appear at false azimuth and range positions. The site azimuth and range occupied by the aircraft is the only true radar beacon reply. The other replies that might appear on a controller's display are caused by the reflection of the transmitter site interrogations and aircraft replies from metallic fences, towers, buildings, etc., in the vicinity of the radar beacon transmitter site

There are a number of ways in which reflected radar beacon replies can be eliminated. One of these methods utilizes radar beacon Improved 3-Pulse Side Lobe Suppression and relies upon the fact that all reflections are delayed due to the increased path length via the reflector (Figure 38).

Side Lobe Suppression (SLS).

The Improved 3-Pulse SLS System was designed to retain the benefits of the Normal 3-Pulse SLS System, and eliminate the majority of reflected radar beacon replies. For more detailed information, you can refer to Report No. RD-65-139, entitled "Experimental Testing of the Improved 3-Pulse Interrogation Side Lobe Suppression System," which was handed out yesterday. The Improved 3-Pulse SLS System increases the range of the P_1 interrogation pulse over the range of the P_1 interrogation pulse that is radiated from the side lobes of the directional antenna. This is accomplished by radiating the P_1 interrogation pulse from both the directional and omni-directional antennas. As the range of the SLS system operation is increased by use of the Improved 3-Pulse SLS, the range of suppression of reflected radar beacon replies is also increased.



AIRCRAFT TRANSPONDER WILL REPLY TO REFLECTION

TRANSPONDER WILL NOT REPLY TO REFLECTION

FIGURE 38. THE IMPROVED 3-PULSE SIDE LOBE SUPPRESSION METHOD TO ELIMINATE REFLECTED RADAR BEACON REPLIES

LA Flight Test.

In February of 1964, the experimental model of the Improved SLS system, which was designed and fabricated by NAFEC, was flight tested at the Los Angeles, Calif. ASR-4 Radar Beacon Site, using NAFEC Aircraft N-249.

The initial orbital and radial flight testing established the 320 and 290 degree radials of the Los Angeles VOR as producing the most numerous reflections (Figures 39 and 40). Flight tests conducted on the 320 degree radial of the VOR at 1,000 feet showed a large reduction of reflected replies whenever the Improved SLS system was used. Some reflected replies remained when the Improved SLS system was used and these occurred when the aircraft flew behind the RML tower (Figure 41).

The RML tower was positioned in the radiation far-field of the omni-directional antenna and the near-field of the directional antenna, and therefore, attenuated or reflected the omni-directional antenna radiation to a much greater extent than the directional antenna. By visual observation of the test aircraft from the roof of the ASR-4 building, it was confirmed that the reflected replies did occur when the RML tower was between the aircraft and the omni-directional antenna.

The results of flight testing on the 290 degree radial of the Los Angeles VOR are shown in Figures 42 and 43. Figure 42 was taken with the Improved 3-Pulse SLS System off, while Figure 43 was taken with the Improved SLS System on. The large amount of side lobe returns shown in these figures was caused by the RML tower once again attenuating or reflecting the omni-directional antenna radiation and preventing normal 3-Pulse SLS operation when the flight test aircraft was between 17 and 25 nmi on the 290 degree radial. Additional reflections and side lobe returns can be seen between ranges of 6 and 11 nmi. These reflections and side lobe returns seemed to be caused by attenuation or reflections of the omni-directional antenna radiation from the other side of the RML tower or possibly shielding of the omni-directional signal by the IBM Building. A reflected target can be seen in Figure 43 on approximately the 50 degree radial from the ASR-4 Site at a range of 13 to 15 nmi. This target was a reflection delayed by approximately 5 nmi from the direct-line signal and once again occurred when the flight test aircraft was behind the IBM Building.

Limitations of SLS.

The results of the flight tests in the vicinity of the Los Angeles ASR-4 Site showed that even though the Improved 3-Pulse SLS did reduce the number of reflected radar beacon replies, there are conditions which limit its effectiveness.

The improved 3-Pulse SLS will not eliminate reflected radar beacon replies when:

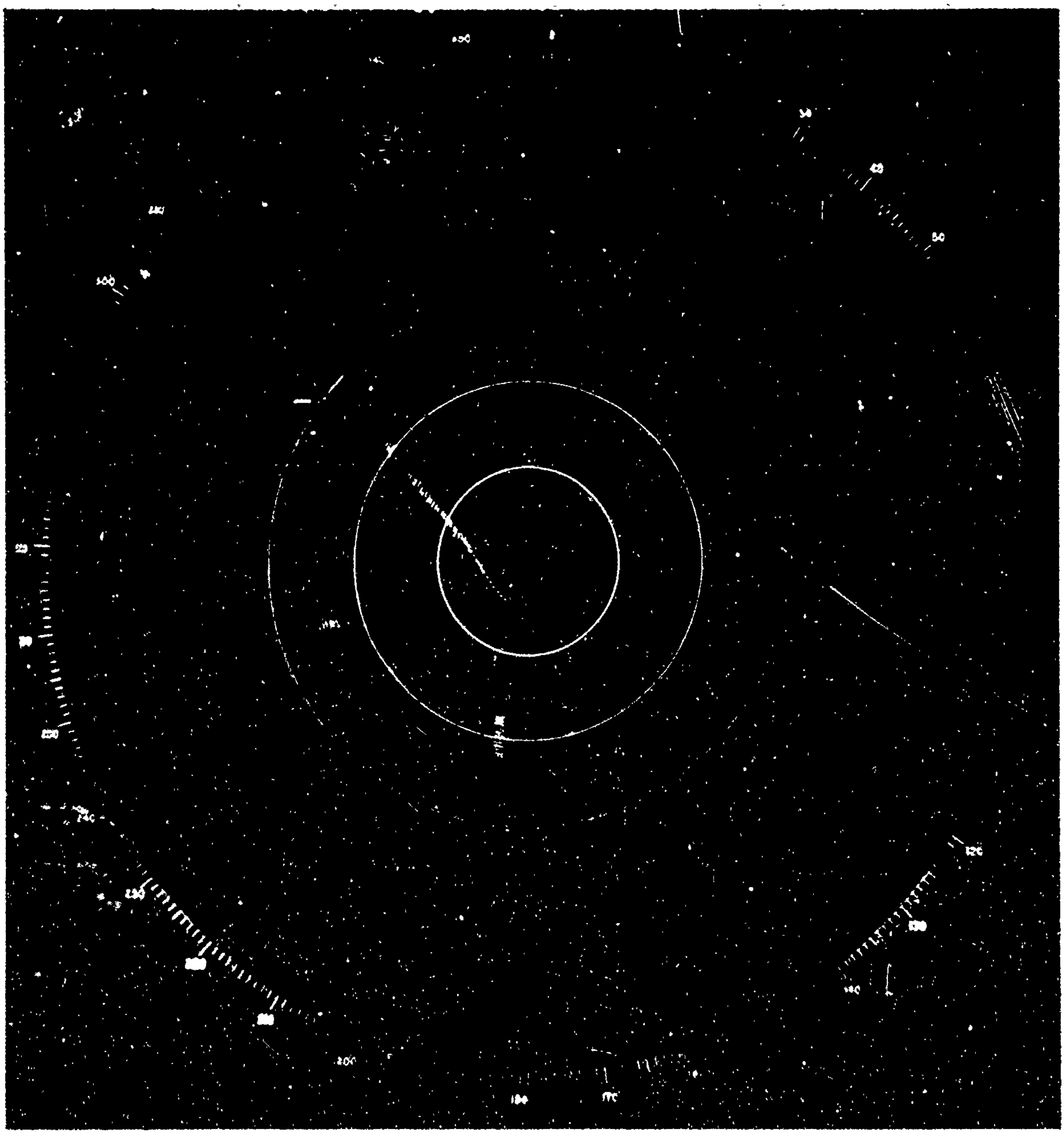


FIGURE 39. LOS ANGELES VOR 320 DEGREES RADIAL FLIGHT NORMAL SLS SYSTEM

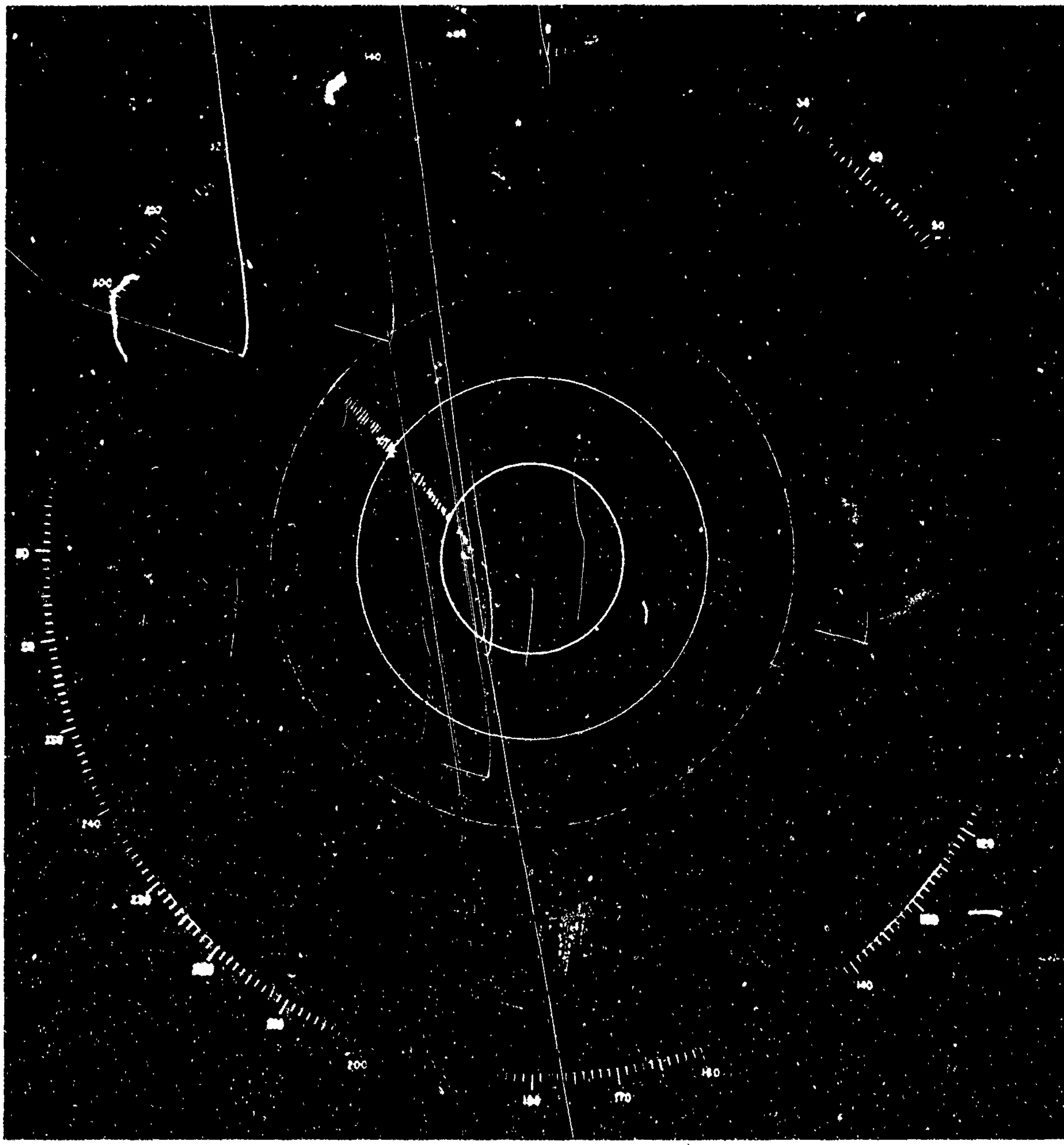


FIGURE 40. LOS ANGELES VOR 320 DEGREES RADIAL FLIGHT IMPROVED SLS SYSTEM

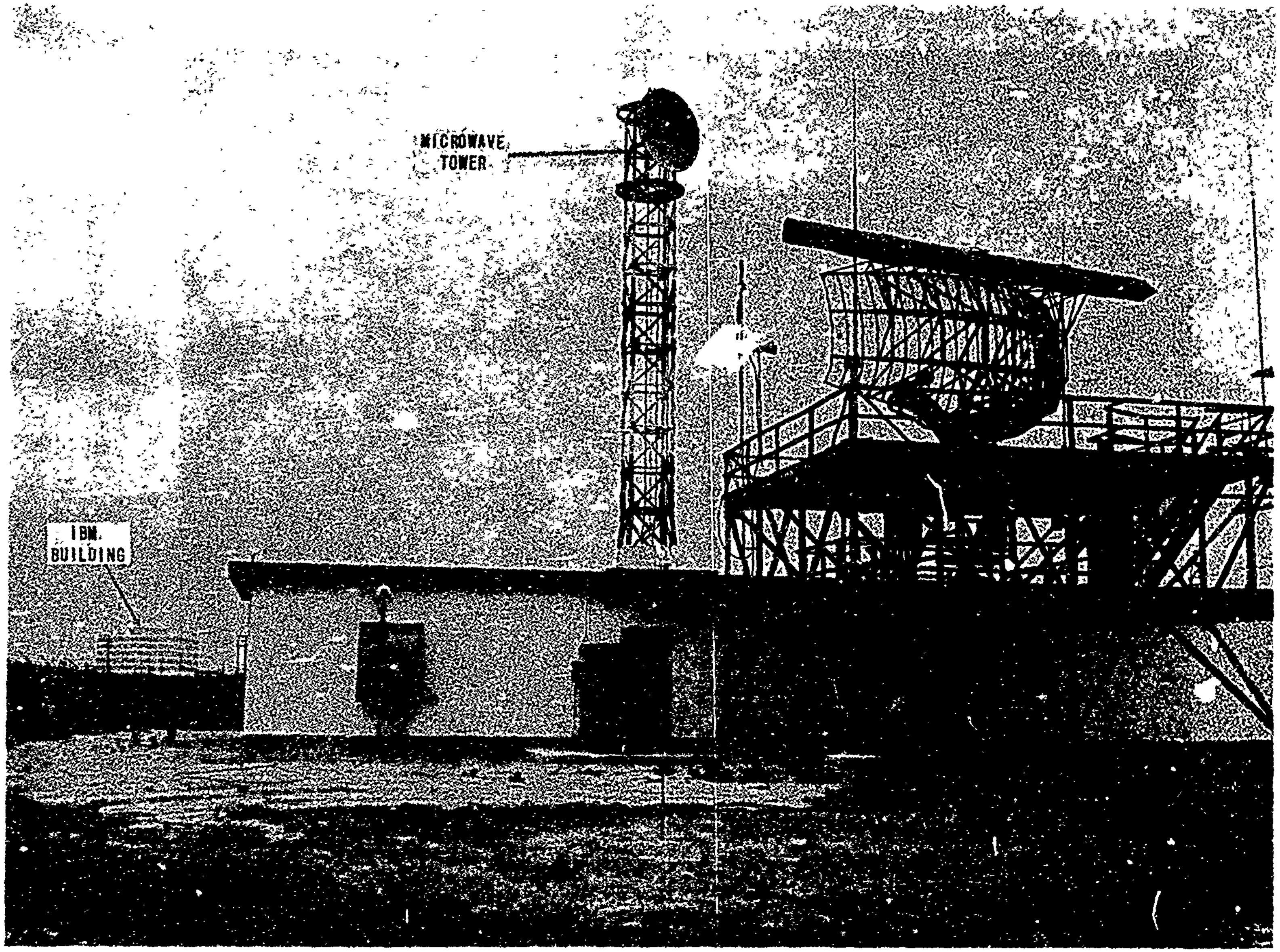


FIGURE 41. LOS ANGELES ASR-4 RADAR BEACON INSTALLATION

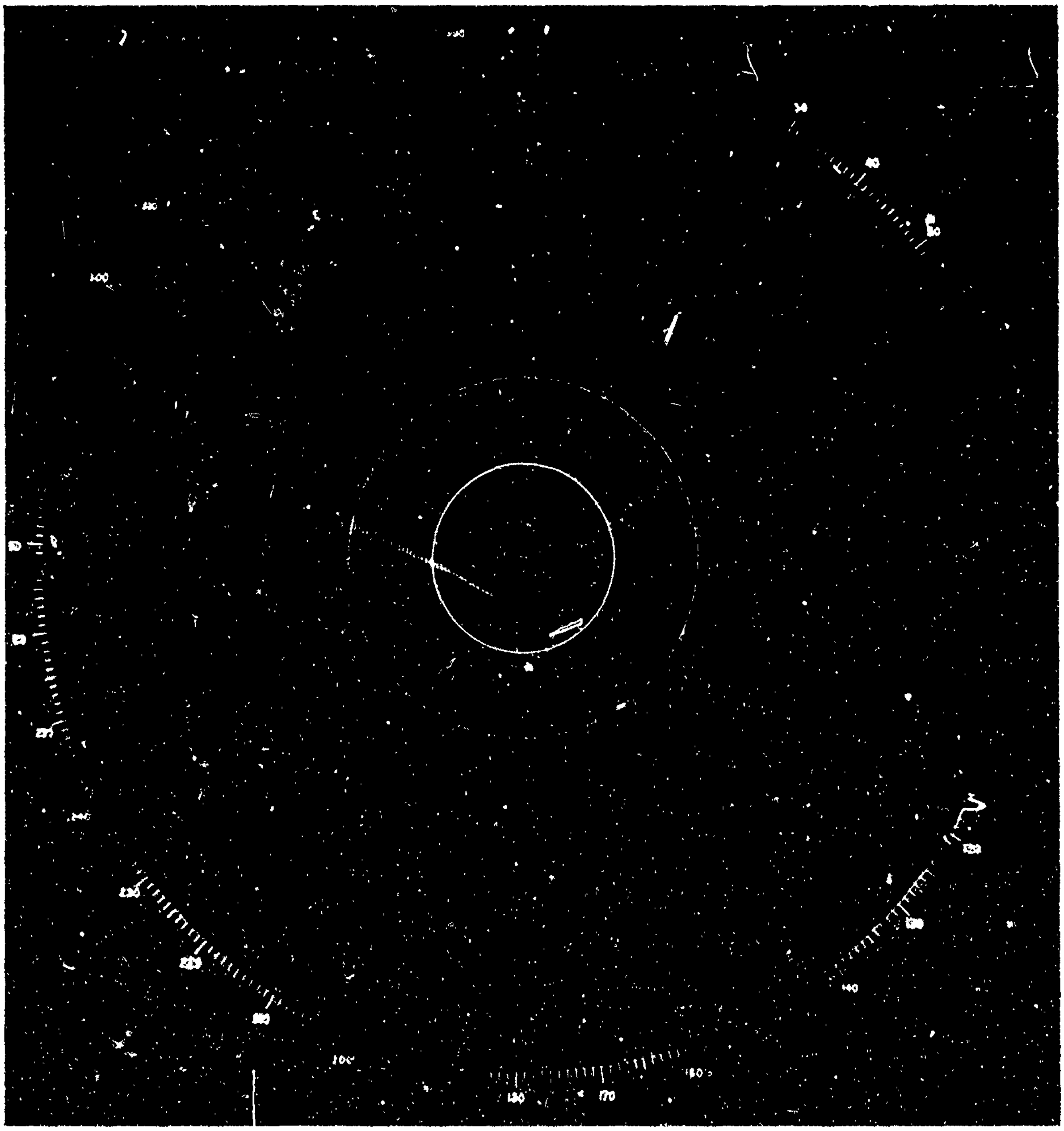


FIGURE 42. LOS ANGELES VOR 290 DEGREES RADIAL FLIGHT NORMAL SLS SYSTEM

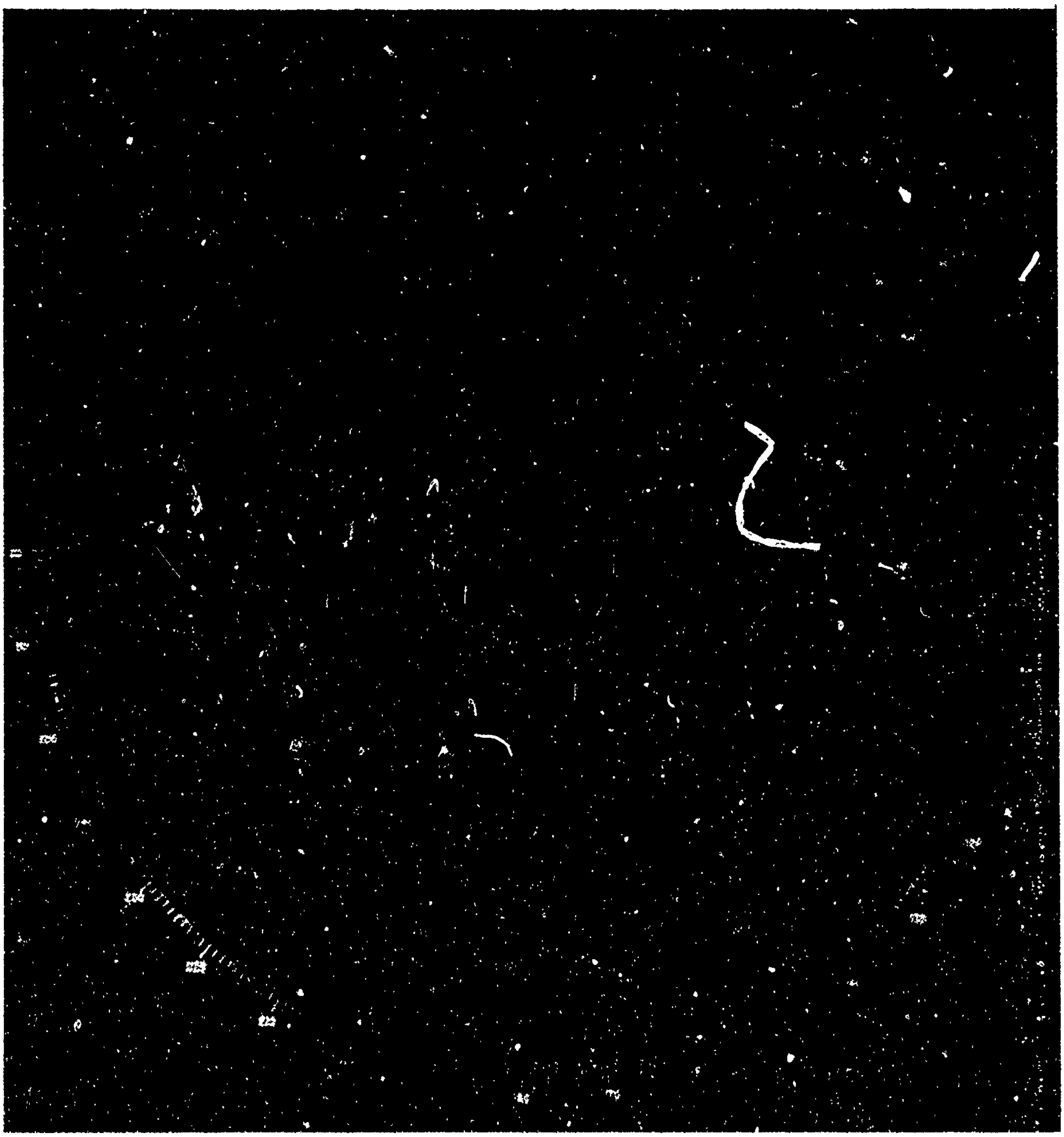


FIGURE 43. LOS ANGELES VOR 290 DEGREES RADIAL FLIGHT IMPROVED SLS SYSTEM

1. Obstructions in the vicinity of the transmitter site prevent direct-line radiation from the omni-directional ground antenna to the aircraft.

2. The reflected interrogation reaches an aircraft transponder, utilizing echo suppression circuitry, so that the reflected P_1 interrogation pulse is received between the direct-line P_1 and P_2 interrogation pulses.

3. The reflected interrogation reaches the aircraft transponder more than 45 μs after the reception of the direct-line P_2 interrogation pulse (beyond the SLS suppression gate length).

4. The reflected interrogation is of sufficient signal strength to interrogate the aircraft transponder at ranges beyond the range of the P_1 and P_2 interrogation pulses radiated from the low gain omni-directional antenna.

In these four cases, the Improved 3-Pulse SLS will not eliminate the reflected radar beacon replies; and further effort must be expended to either modify the reflecting surface or somehow prevent the aircraft transponder from responding to the reflected interrogations.

Chicago Flight Tests.

During the session on Missing and Fading Targets yesterday, I mentioned that reflected radar beacon replies were recorded, while flight testing in the vicinity of the Chicago O'Hare Airport in March of 1970.

While analyzing the Chicago O'Hare flight test data, it was noted that reflected radar beacon replies consistently occurred between the ASR-4 Site azimuths of 210 and 250 degrees. Further investigation of these azimuths revealed that towers at the Remote Transmitter Site No. 1, adjacent to the ASR-4 Site, were approximately at the same azimuths as those where the problems occurred (Figure 44).

The four remote transmitter site towers were approximately 40 feet tall with a 3-foot tall platform on the top of each tower. The towers were 4' x 4' and the platforms on top of the towers were 8' x 8'.

From earlier experimentation performed at Los Angeles and NAFEC using the Improved 3-Pulse SLS, it was determined that the Improved SLS System will not eliminate reflected radar beacon targets if the reflector is less than 1,000 feet from the radar beacon antenna. The remote transmitter site towers were between 240 and 325 feet from the O'Hare ASR-4 Site tower (Figure 45).

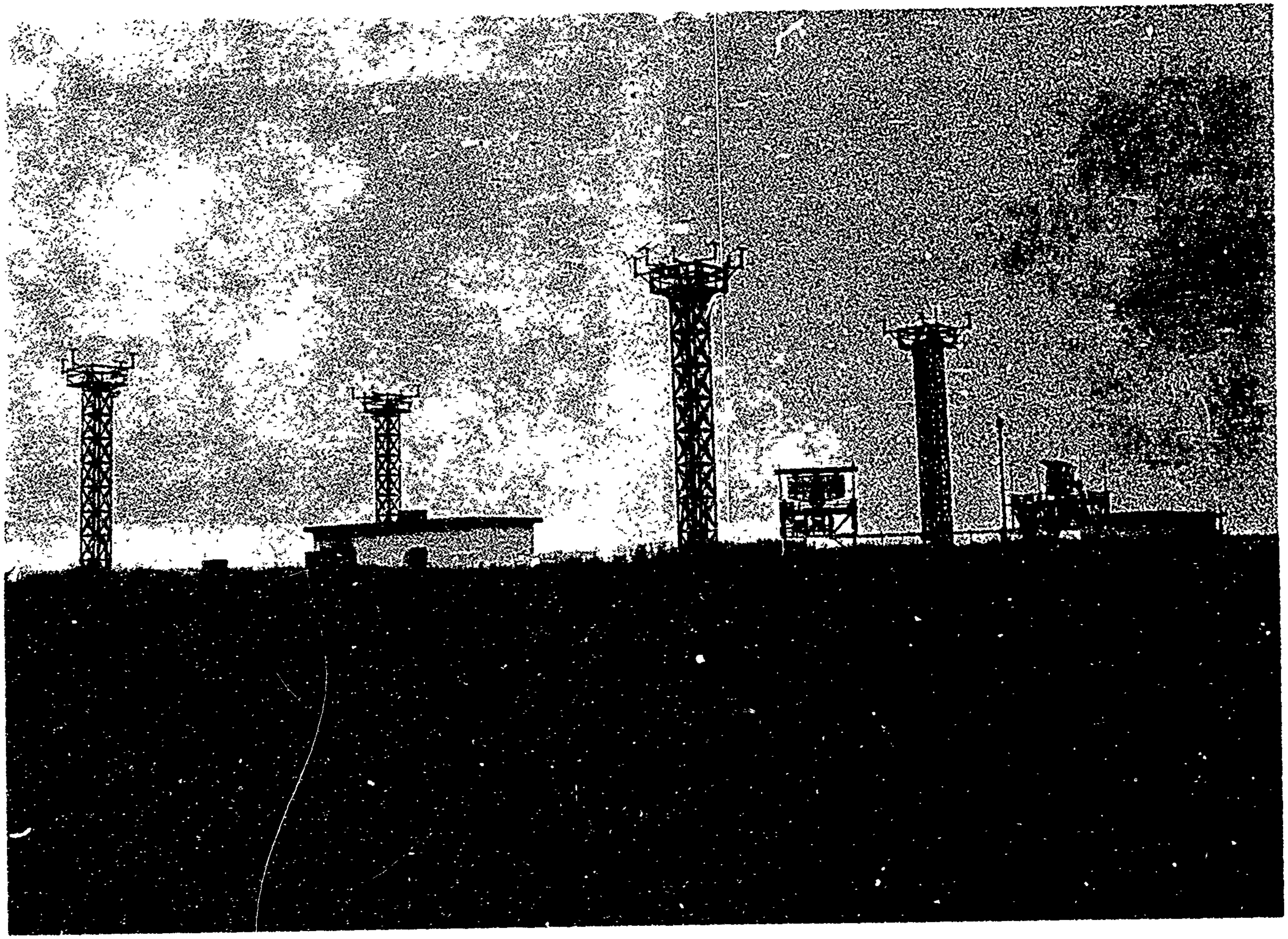


FIGURE 44. REMOTE TRANSMITTER SITE TOWERS ADJACENT TO ASR-4 RADAR BEACON SITE

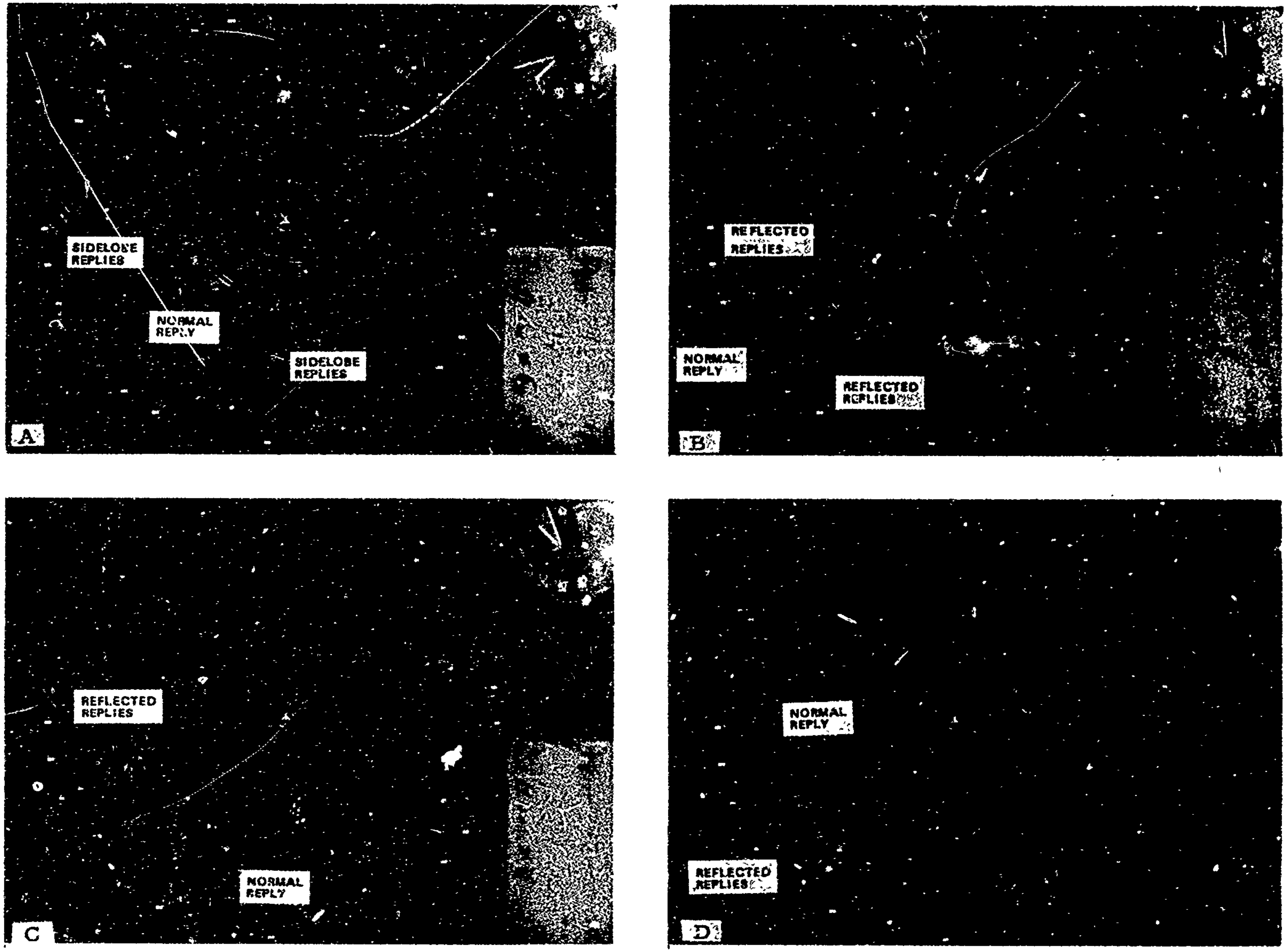


FIGURE 45. RADAR BEACON SIDE LOBE AND REFLECTED REPLIES DUE TO REMOTE TRANSMITTER SITE TOWERS

Photographs B, C, and D of Figure 45 shows reflected beacon replies that were received from the flight test aircraft while it was flying at azimuths of the ASR-4 Site associated with the remote transmitter site towers. B and C of this figure show reflected radar beacon replies that occurred at the azimuth of two or three of the remote transmitter site towers. D shows reflected radar beacon replies that occurred at the azimuth of all four of the remote transmitter site towers. The photographs were taken on all three of the days that flight tests were performed in the Chicago O'Hare problem area. This indicated that the reflection problem was consistent over a period of time.

Because of the reflected radar beacon reply problem that occurred at the Chicago O'Hare ASR-4 Site, a recommendation was made that the ASR-4 Site on the towers of the Remote Transmitter Site No. 1 be moved. The Central Region decided that they would decommission the ASR-4 Site when the ASR-7 Radar was installed and that they would live with the problem until the new ASR-7 Site was installed (Figure 46). This is the new Chicago O'Hare ASR-7 Site that replaced the ASR-4 Site. I would like to point out the similarity between the Chicago ASR-7 Site installation in August of 1971 and the Los Angeles ASR-4 Site in January of 1964. Somehow, I feel we have gone a full circle and returned to where we started. I hope the RML tower has been removed or will be removed in the future at the Chicago O'Hare ASR-7 Radar Site.

Siting Precautions.

A report was written and published by NAFEC in September of 1969 detailing the precautions that should be observed when siting a new radar beacon site. The report, No. RD-69-43, is entitled "Experimentation and Analysis of Siting Criteria" and will be passed out during the break (Figure 47). This report shows a typical radar and radar beacon site installation which was designed to minimize the possibility of reflections from (1) the terrain which cause vertical lobing, and (2) from fences and low buildings which cause reflected beacon replies. If the installation precautions, that were outlined in this report are observed, it should eliminate or substantially reduce the problem of returning to the site for corrective fixes at a later date. The criteria specified in this report might make the selection of a new site more difficult, but it will reduce the overall cost to the FAA, since most of the fixes required after once the site is installed, are expensive, as well as time consuming.

Trevose Investigation.

In December of 1970, a request was made by the Eastern Region for NAFEC participation in the investigation of the Trevose, Penna., reflected radar beacon reply problem. Reflected radar beacon replies were reported to have appeared in the Salisbury, Maryland, area when aircraft were flying in the vicinity of J. F. K. International Airport on Airway J-42, and when aircraft were flying on Airway J-80 west of the Trevose Site (Figure 48). Some reflected radar beacon replies were also reported to have appeared northeast of the Trevose Site when aircraft were flying on Airway J-80 west of Trevose. The problem of reflected replies existed since the site was installed and was one of the main factors that prevented commissioning of the facility. (Figure 49)

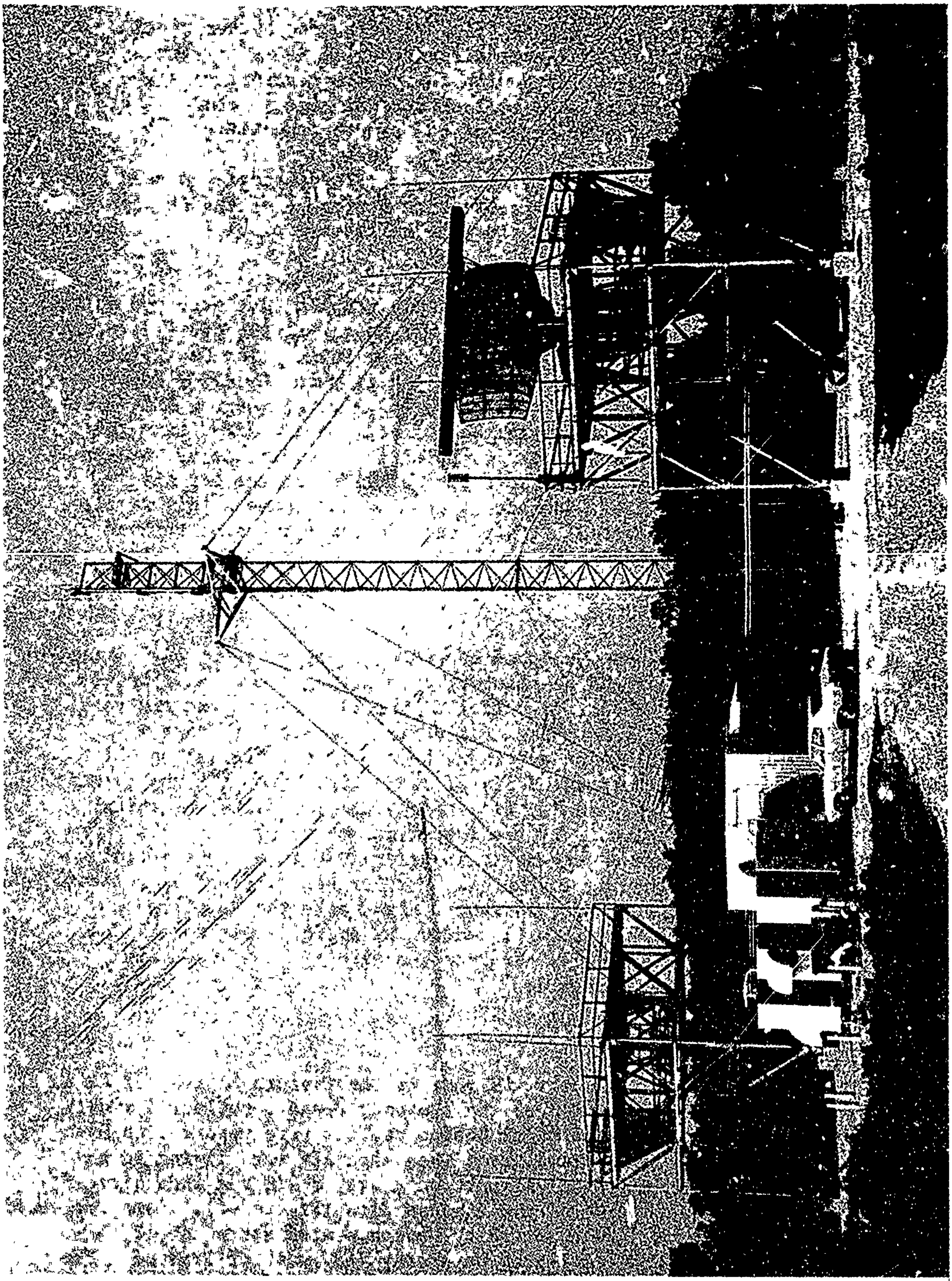


FIGURE 46. THE NEW ASR-7 SITE

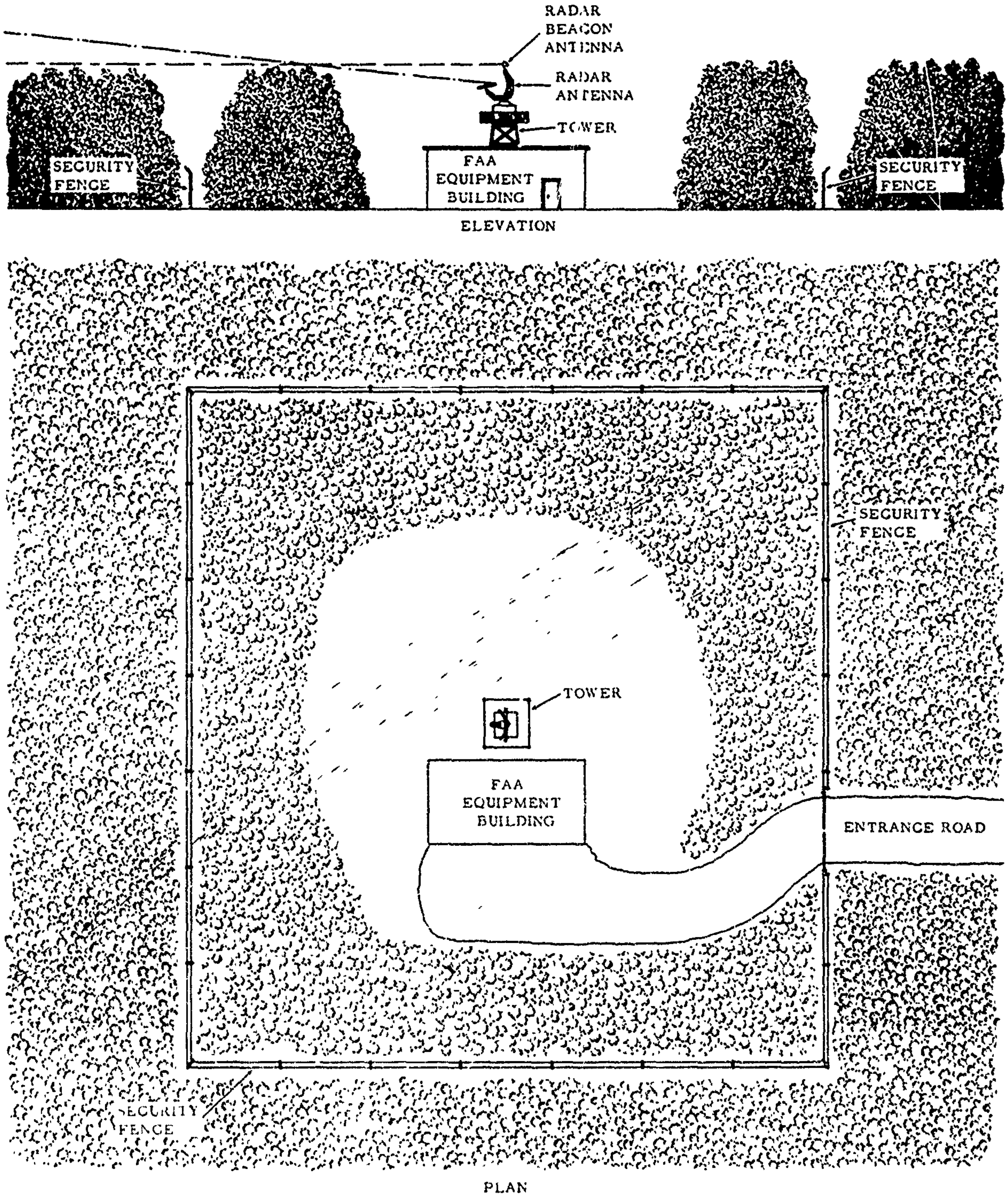


FIGURE 47. RADAR BEACON SITE MODEL

FIGURE 48. TREVOSE RADAR BEACON SITE

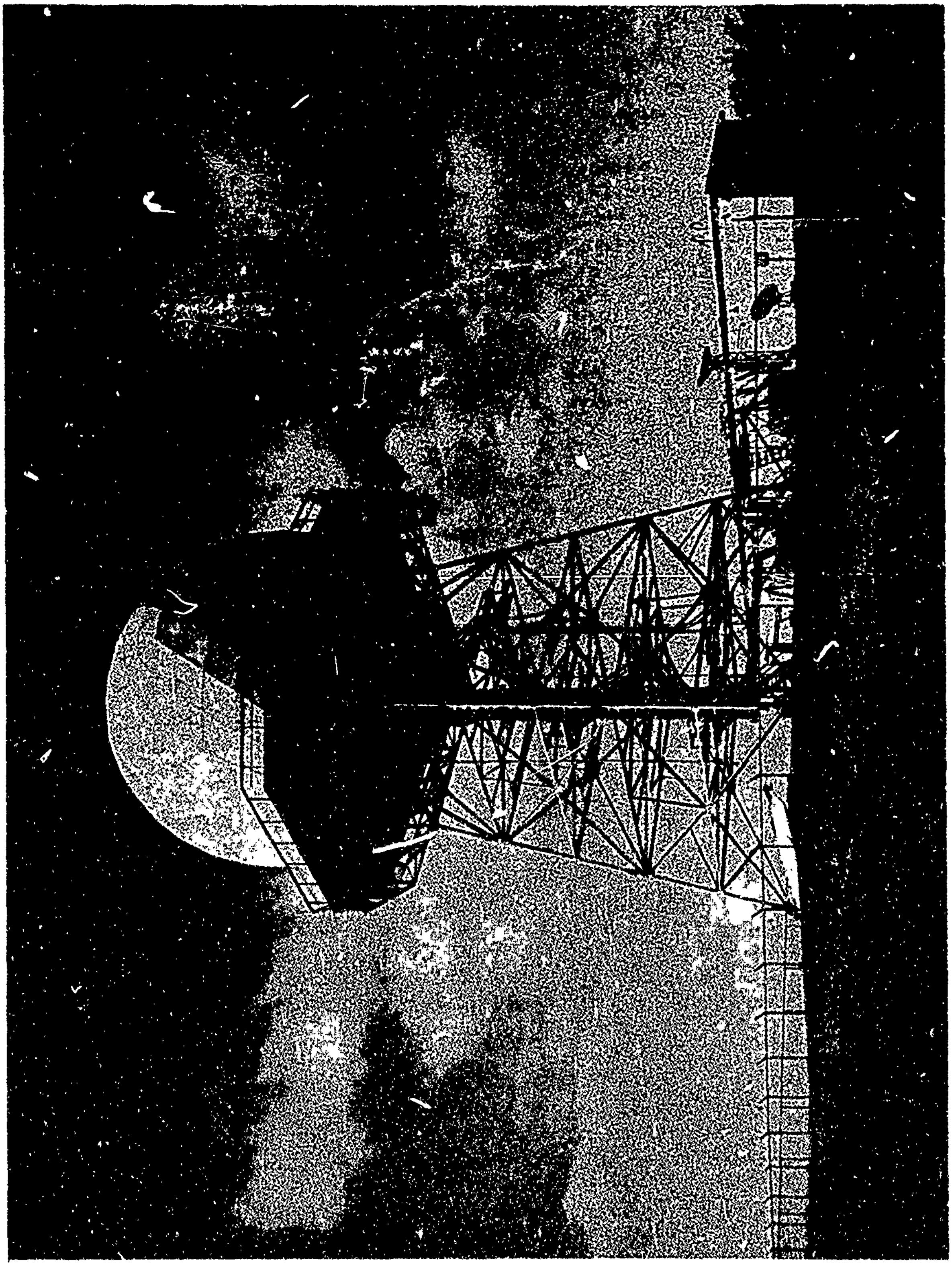


FIGURE 49. THE TREVOSE ANTENNA

Using Discrete Codes.

An evaluation test was conducted by the Eastern Region in the New York Center which consisted of assigning discrete radar beacon codes to all aircraft operating in the areas where reflected radar beacon replies were consistently generated. It was assumed that the assignment of discrete radar beacon codes to aircraft flying in the sectors where reflected radar beacon replies were generated would eliminate the appearance of reflected radar beacon replies in the sectors where the discrete radar beacon codes were not selected for presentation on the display. The evaluation proved successful, but the use of discrete radar beacon codes was found to be undesirable by the air traffic controllers for the following reasons:

1. The use of discrete radar beacon codes was non-standard, and therefore necessitated a waiver from the requirements set forth in handbook 7110.9A.

2. The use of discrete radar beacon codes increased the controllers' workload at the sector utilizing the discrete code, decreased traffic handling capacity, and increased confusion at the time of radar handoff.

3. The use of discrete radar beacon codes increased the controllers' workload at sectors and facilities adjacent to the sectors using the discrete code; and

4. An increase in pilot workload and additional communications frequency congestion was found to result from the use of discrete radar beacon codes.

At the completion of the evaluation tests, the air traffic controllers requested that an electronic solution be devised to resolve the reflected radar beacon reply problem at Trevose.

Trevose Flight Test.

NAFEC aircraft were flown within the coverage area of the Trevose Site, to determine the extent of the reflected radar beacon replies, and their origin.

This was after the documentation gathered by the Eastern Region from the New York Center Trevose display had been reviewed. The photographs, taken by the Eastern Region in the New York Center, showed that two areas responsible for the majority of the reflected radar beacon reply reports were:

1. Airway J-42 east of Trevose, at altitudes above 17,000 feet (centering on 25,000 feet) and at ranges between 85 to 120 nmi, and

2. Airway J-80 west of Trevose (at no specific altitude) at ranges between 55 and 100 nmi.

Some reflected radar beacon replies were also reported to have appeared on the display northeast of Trevose, when aircraft were flying on Airway J-80 at ranges approximating 60 nmi.

The Air Traffic Control Beacon Interrogator-3 (ATCBI-3) installed at Trevose was modified by the site personnel to include an Improved 3-Pulse SLS System. The Improved SLS System was installed to suppress reflected radar beacon replies, but the Improved SLS System is limited in its ability to do so.

As stated earlier, the range of the Improved SLS System is limited by the low gain of the omni-directional antenna. Experimental tests were conducted at Trevose to determine the extent of the range of the omni-directional antenna by using the antenna to interrogate transponders and receive replies. The test was made for a very short interval of time so that the overinterrogation of aircraft transponders that could result from this type of test would be kept to a minimum. The results of this test showed that the interrogation range of the omni-directional antenna extended to a maximum of 75 nmi. This indicated that the Improved SLS System was also limited to a maximum range of approximately 75 nmi.

The range of the reflected radar beacon replies, from aircraft flying on Airway J-42 was 85 to 120 nmi, and the range of the reflected radar beacon replies from aircraft flying on Airway J-80 was 55 to 100 nmi. These ranges are beyond the range of the Improved SLS System with the exception of the lower range limit of reflected replies on Airway J-80 (55 nmi). An inspection of the site radials, which were at the azimuth of Airway J-80, showed that there was a tall growth of trees in this area (Figure 50). The attenuation of the signals by the trees at this azimuth was suspected as being the reason for the reduction in range of both the reflected radar beacon replies and the Improved SLS System. The attenuation of the Improved SLS System signals by trees could be considered as a limited case of obstructions in the vicinity of the transmitter site preventing direct-line radiation from the omni-directional ground antenna to the aircraft.

Salisbury Problem at Trevose Site.

From the data gathered in the New York Center by the Eastern Region, it was evident that the Salisbury, Maryland, area was the major control area in which reflected radar beacon replies occurred. The azimuth bearing from Trevose to Salisbury was approximately 205 degrees, and reflected replies occurred at azimuths between 202 and 212 degrees.

Figure 51 shows the terrain in the vicinity of the Trevose En Route Site at these site azimuths. From this photograph, it can be seen that there are no large reflecting objects or buildings above the horizon except a water tower, some smoke stacks and a distant building. The building was at least 2 miles from the Trevose Site and both the smoke stacks and the water tower had round surfaces, which would have a tendency to scatter the energy that would strike them. There were buildings and a farm complex in close proximity to the Trevose Site on the azimuth bearings in question, but all of these buildings were at angles below the radiation horizon of the radar beacon directional antenna.

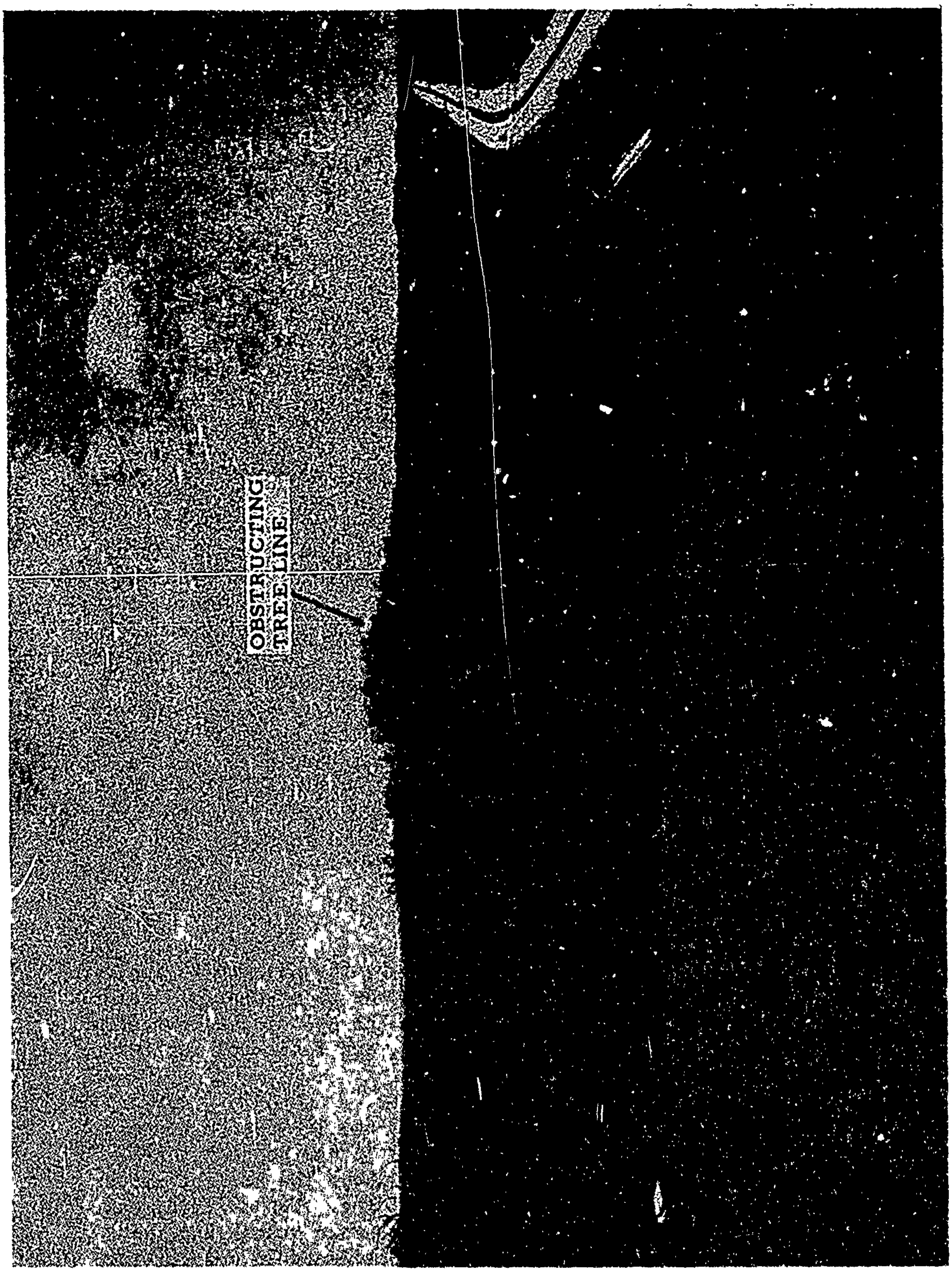


FIGURE 50. TREES AROUND AIRWAY J-80

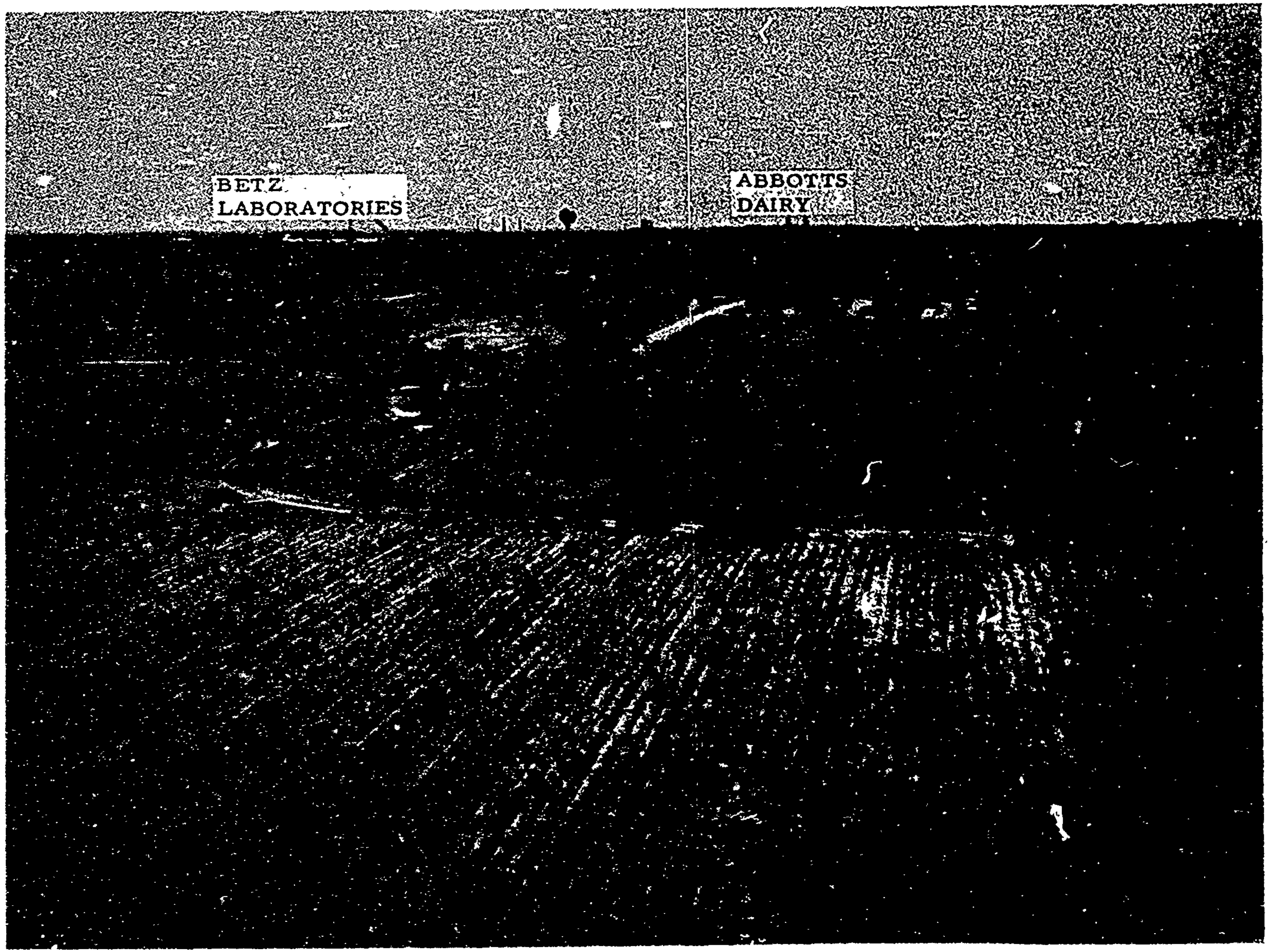


FIGURE 51. THE VICINITY OF THE TREVOSE ENROUTE SITE

Flight tests were conducted by NAFEC in the areas designated by the Eastern Region, as the flight paths which produced reflected radar beacon replies. A Gulfstream, DC-6, and DC-7 aircraft equipped with a normal aircraft TRU-1 Radar Beacon Transponder, were flown in the areas where the majority of the reflected replies occurred. Only one aircraft was flown at a time and the flights were made on Airways J-42 and J-80, at altitudes between 21,000 and 25,000 feet.

The initial flight tests that were performed were flown in the center of Airways J-42 and J-80, but failed to produce reflected radar beacon replies. Subsequent flight tests were flown perpendicular to the airways. The latter flights showed that the majority of the reflected replies were produced over extremely narrow site azimuth angles which were off to one side of the center of the airways that were flown. The remainder of the flight tests were conducted on the site radials which produced the reflected radar beacon replies.

Photos Show Reflected Replies.

Flight tests were conducted by NAFEC in the Trevose coverage area from 1 December 1970 to 26 January 1971. The pertinent results of these flight tests are shown in the following figures. I would like you to bear with me on the photos that will be shown. During the months that the flight tests were conducted, the ARSR PPI Display that was permanently installed at Trevose, was inoperative due to a malfunction. Data from flight tests had to be gathered using an OA-175 FPS-3 PPI that was temporarily installed. The OA-175 FPS-3 PPI did not have an illuminated compass rose; therefore, the intensity of the sweep was increased during the tests to backlight the compass rose scale so that the azimuth of the replies could be determined.

Decoding of the radar beacon signals was accomplished during the testing at the Trevose transmitter site by using a 64-code decoder that was borrowed from NAFEC.

Figure 52 shows two examples of reflected radar beacon replies that occurred at an azimuth of approximately 205 degrees. During this test, the flight test aircraft was flown at an altitude of 25,000 feet north of the center of Airway J-42 at a range of approximately 85 nmi (10 nmi range marks). Subsequent flight tests flown north of the center of Airway J-42 showed that the reflected radar beacon replies extended from a range of 85 to 120 nmi. The site azimuth which produced the reflected replies was found to be extremely narrow.

Reflected replies, which occurred at an azimuth of approximately 205 degrees when the flight test aircraft was flown south of the center of Airway J-80, are shown in Figure 53. Further flight tests showed that the range of the reflected replies produced by the flight test aircraft while flying on Airway J-80 extended from 55 to 100 nmi. Even though a discrete radar beacon reply code was used, replies other than the flight test aircraft and its reflected replies can be seen on Figure 53.

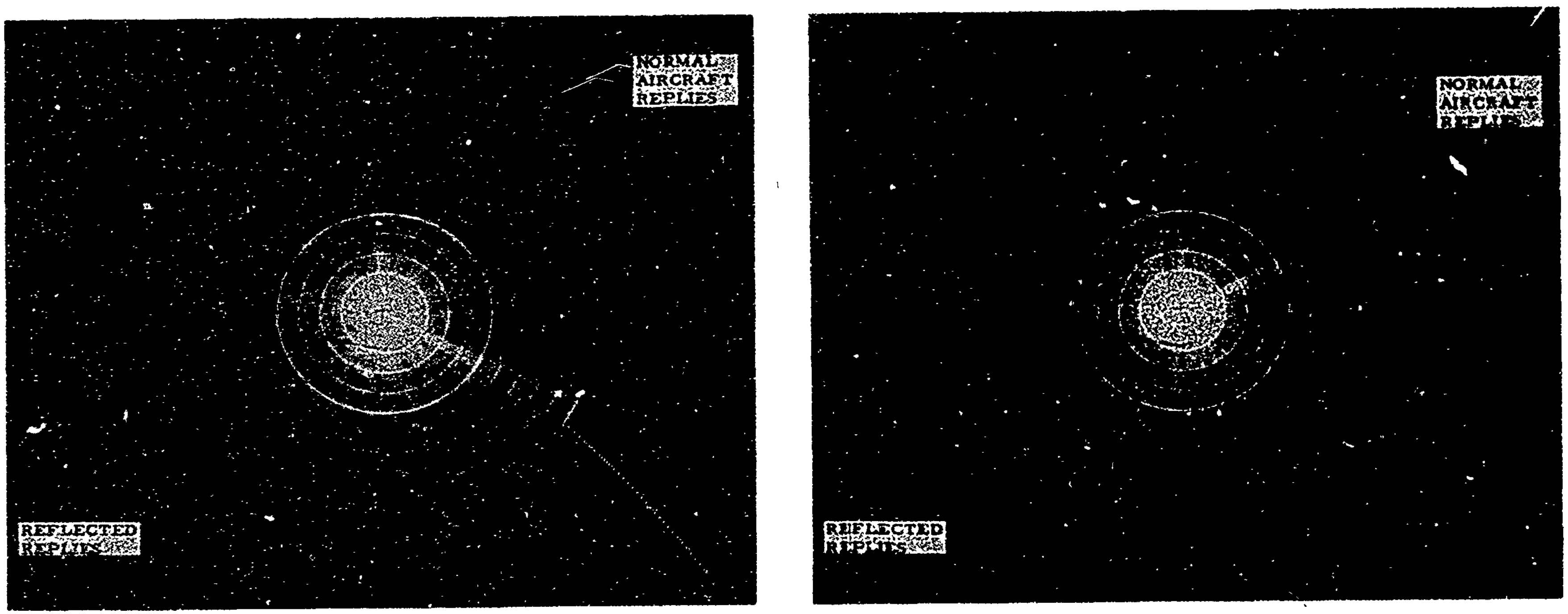


FIGURE 52. TWO EXAMPLES OF REFLECTED RADAR BEACON REPLIES

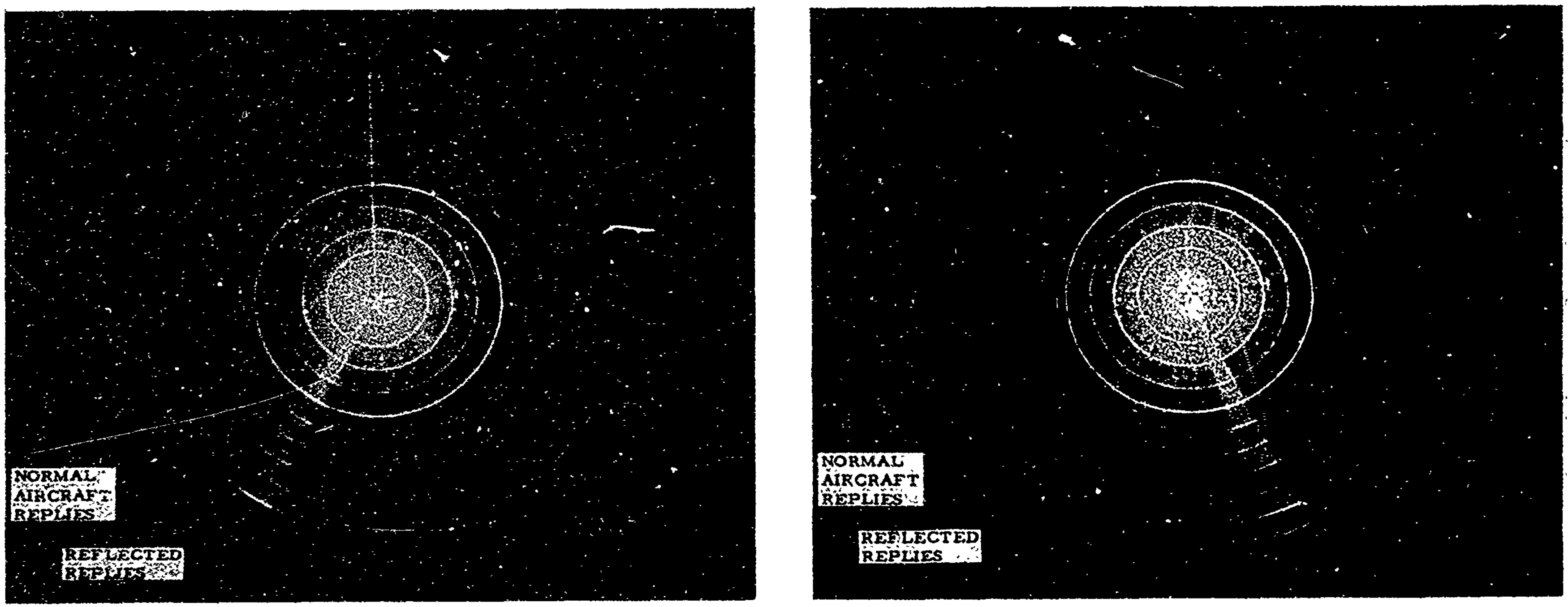


FIGURE 53. REFLECTED REPLIES AT AN AZIMUTH OF ABOUT 205 DEGREES

It was assumed that the other replies appeared on the display due to the use of the code by sectors not controlling the flight test aircraft.

Figure 54 shows reflected replies that were recorded at an azimuth of approximately 23 degrees when the aircraft was flying south of the center of Airway J-80, at a range of 58 nmi. These photographs were taken with a horn antenna radiating the P_1 and P_2 Improved 3-Pulse SLS System pulses on an azimuth of 275 degrees. The reflections that had appeared at 205 degrees (Figure 53) were liminated by the horn antenna radiation, but the reflected replies that occurred in the northeast remained. The reason that the horn antenna did not eliminate the reflected replies at 23 degrees is that the horn antenna signal was radiated when the directional antenna was facing the azimuth of 205 degrees, but not when it faced the azimuth of 23 degrees. A further explanation of the operation of the horn antenna will be given later.

Possible Trevose Fixes.

There are a number of methods by which the environment of the Trevose Radar Site could have been modified to eliminate reflected radar beacon replies. Two of these are:

1. Erection of screens placed so as to interrupt the path of the reflections, from the transmitter site to the aircraft, via the reflecting surface, and

2. Increasing the range of the Improved 3-Pulse SLS System to extend the effective range of suppression of aircraft transponders.

The first method, outlined, could have been implemented by erecting a fence, in the vicinity of the Trevose Radar Site, between the reflecting surface and the radar beacon directional antenna. This would have required further flight testing to determine the exact location of the reflecting surface and the erection of fences would also require obtaining permission from the owner of the land adjacent to the Site. Preliminary measurements, that were made to determine the approximate location of the reflecting surface, indicated that the reflecting surface was in the vicinity of the Betz Laboratories, Inc., Research and Development Buildings or the Abbott Dairy Buildings (Figure 51). One or two screens, 50 to 60 feet high, would have probably been required to effectively shield these surfaces, depending upon the distance to the fence from the site. Screens of this size would hardly have been considered beneficial to this neighborhood, therefore, it was assumed that permission to erect fences, of this size, on the farm land adjacent to the site (Figure 55) would probably never have been obtained.

The second method by which the Trevose Radar Site could have been modified to eliminate the reflected radar beacon reply problem would have been to extend the present range of the Improved 3-Pulse SLS System. The extension of the range of the Improved SLS System could have been obtained by radiating the

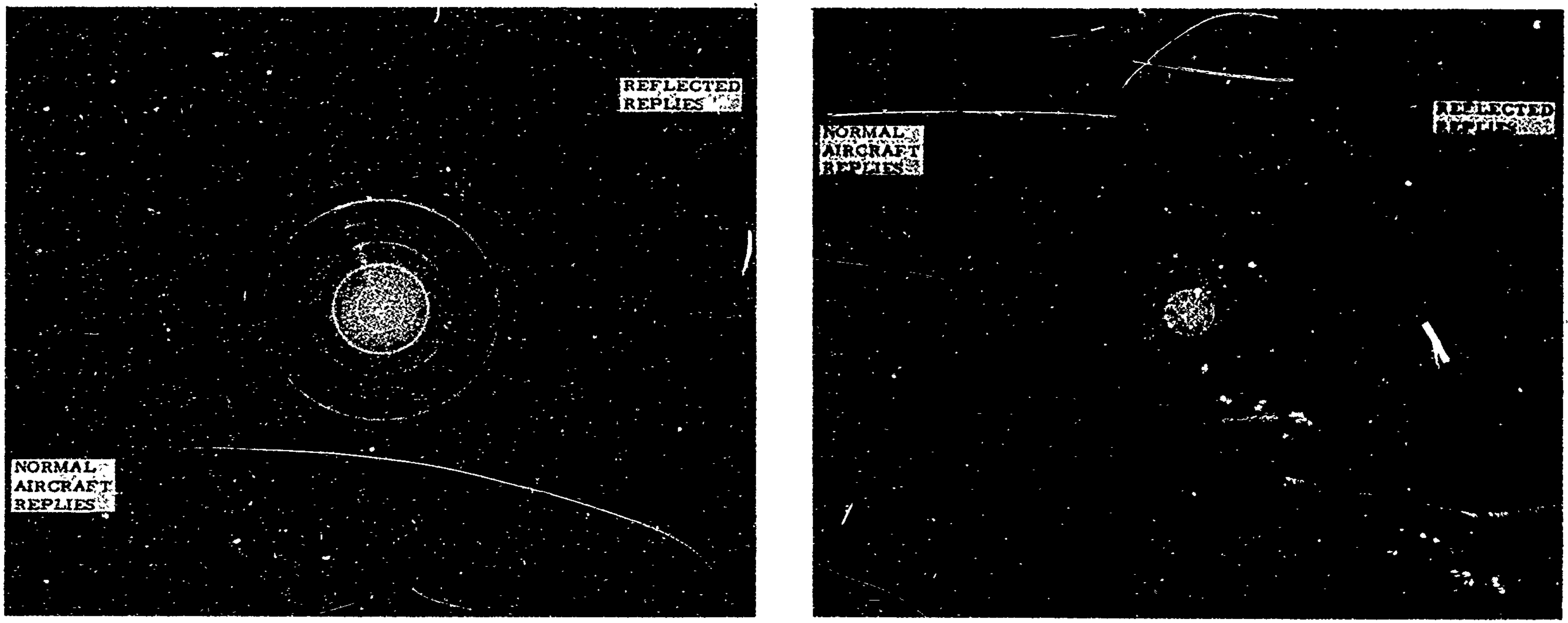


FIGURE 54. REFLECTED REPLIES AT AN AZIMUTH OF 23 DEGREES

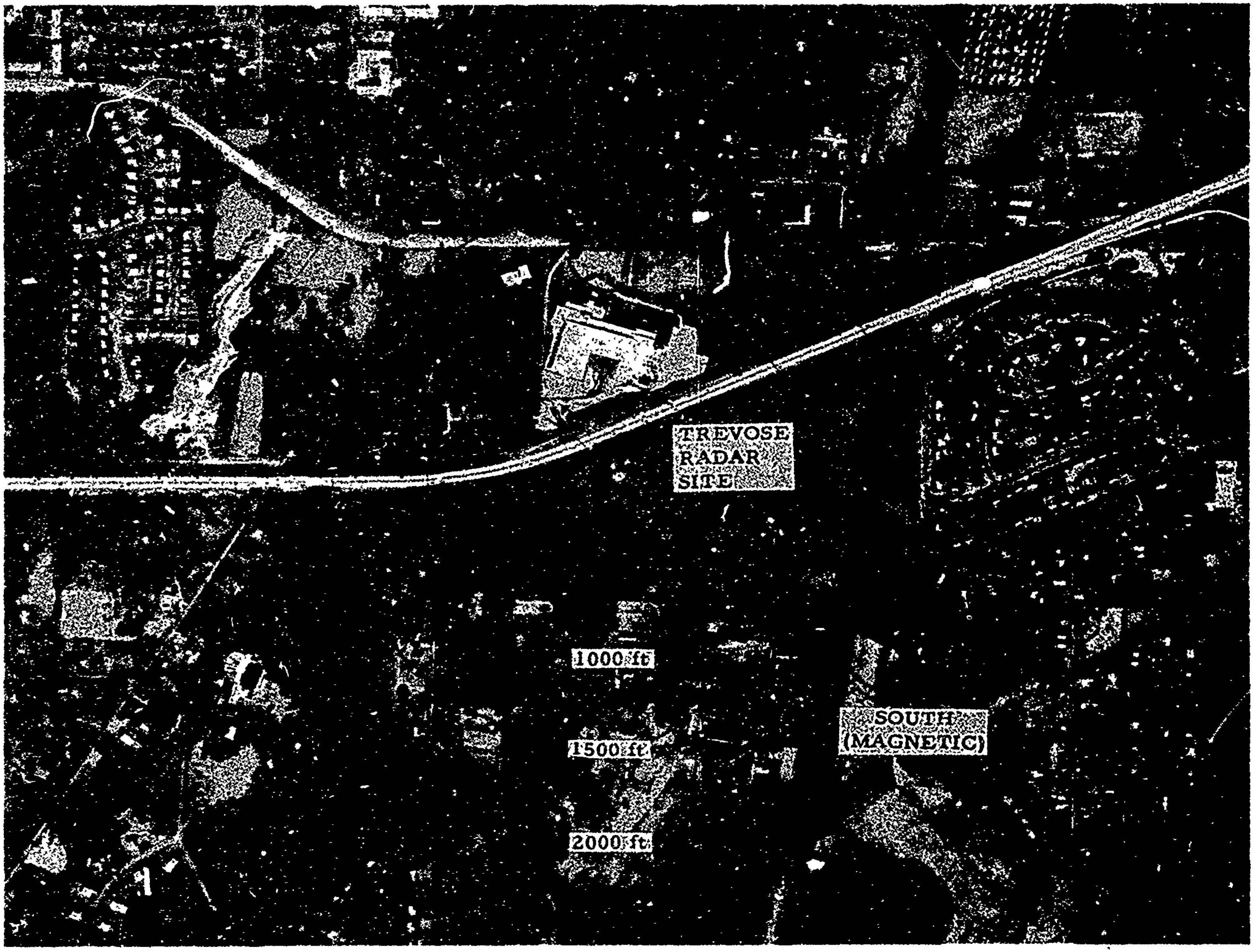


FIGURE 55. LAND AREA AROUND TREVOSE

suppression pulses from a high-gain horn antenna in addition to the normal radiation from the omni-directional antenna. This second method, utilizing high-gain horn antennas, was the system employed by NAFEC at the Trevose, Penna., En Route Radar Site to eliminate the reflected radar beacon reply problem.

Modified Horn Antenna Fix.

Two high-gain horn antennas, identical to the horn antenna shown on the right of Figure 56 were installed on the antenna tower, but within the radome, of the Trevose Site. This figure shows two different antenna configurations mounted on a support structure. The horn antenna shown on the left, was not used for the NAFEC modification. The horn antenna on the left is the basic Standard Gain Horn Antenna, Model 12-0.9, as purchased from Scientific Atlanta, Inc. The horn antenna shown on the right is the same Model 12-0.9 Horn Antenna, but is was modified by NAFEC by extending the flare of the horn to increase the gain of the basic horn antenna. The modification of the horn antenna to provide increased gain was required because (1) the power from the Improved SLS modification system was divided between two horn antennas, thereby effecting a 3 dB signal input loss to each horn antenna, and (2) the shielding of the signals on the site azimuth of 275 degrees by the tree line decreased the effective radiation of the horn antenna which was mounted on this azimuth. For the sake of uniformity, both horn antennas were modified and mounted, as shown on the right of Figure 56 on site azimuths of 85 and 275 degrees.

Antenna patterns were taken at NAFEC on both the unmodified and modified horn antennas. The patterns are shown in Figures 57 and 58. The patterns were taken to insure that the modification did provide additional gain and did not produce distortion in the radiation pattern of the antenna. The extension of the horn flare provided approximately 3 dB of additional gain for the modified Model 12-0.9 Standard Gain Horn Antenna. The horn antenna prior to modification had 13.7 dB of gain relative to an isotropic radiator.

Standing Wave Ratio (SWR) measurements were taken before and after the modification of the horn antennas. The SWR of the unmodified horn antenna measured 1.44:1 while the SWR of the modified horn antenna measured 1.3:1. The modification actually improved the SWR of the antenna as well as increased the gain.

The block diagram of Figure 59 shows how the modified horn antennas were used in a system to increase the range of the Improved 3-Pulse SLS System for the purpose of suppressing reflected radar beacon replies. The Interrogator an AN/UPX-14 was used to generate the 1030 MHz radiation for the modified horn antennas. This was in addition to the Improved 3-Pulse SLS System 1030 MHz radiation provided by the normal ATCBI-3 Interrogator on the omni-directional antenna.

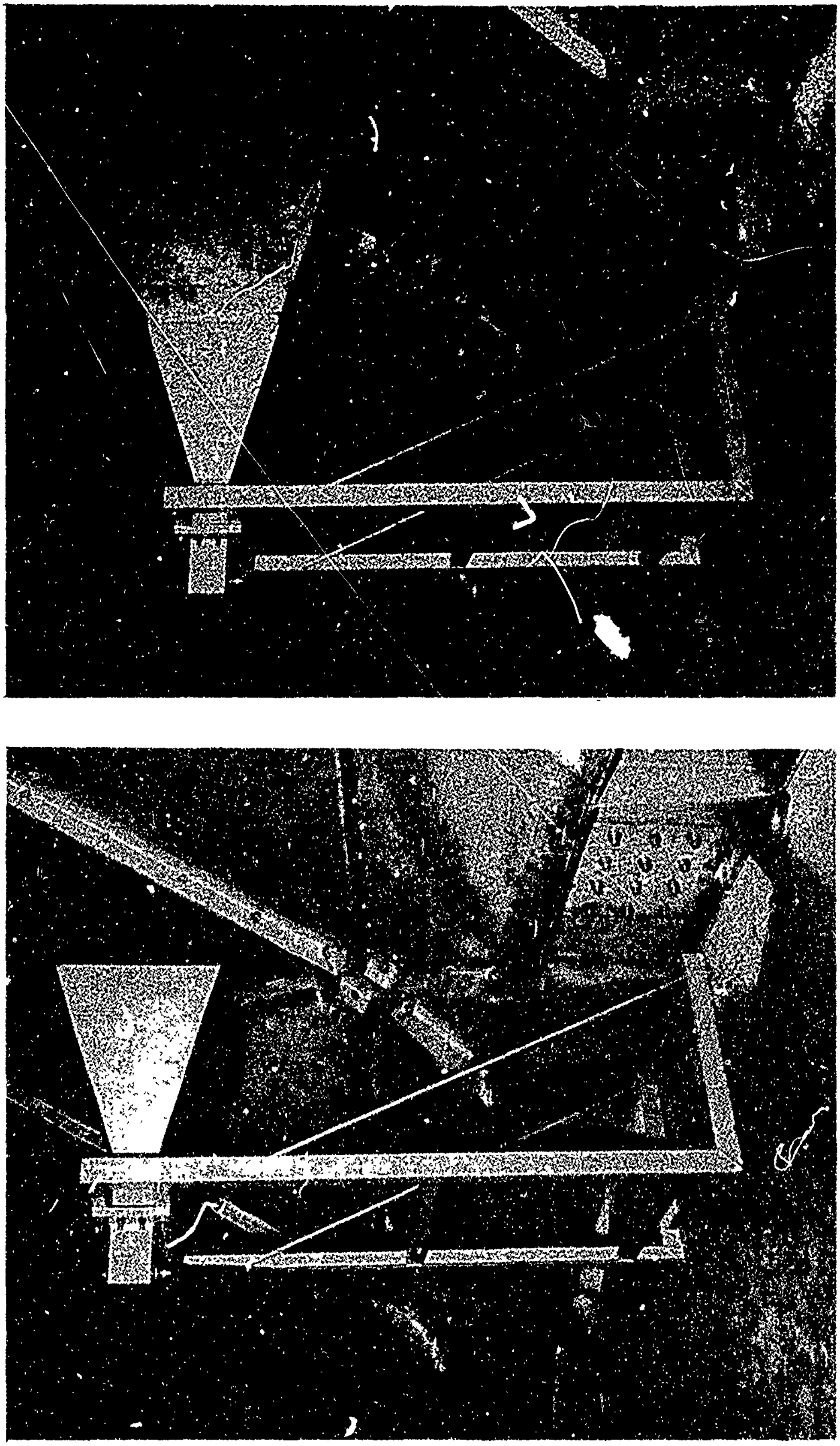


FIGURE 56. HORN ANTENNAS

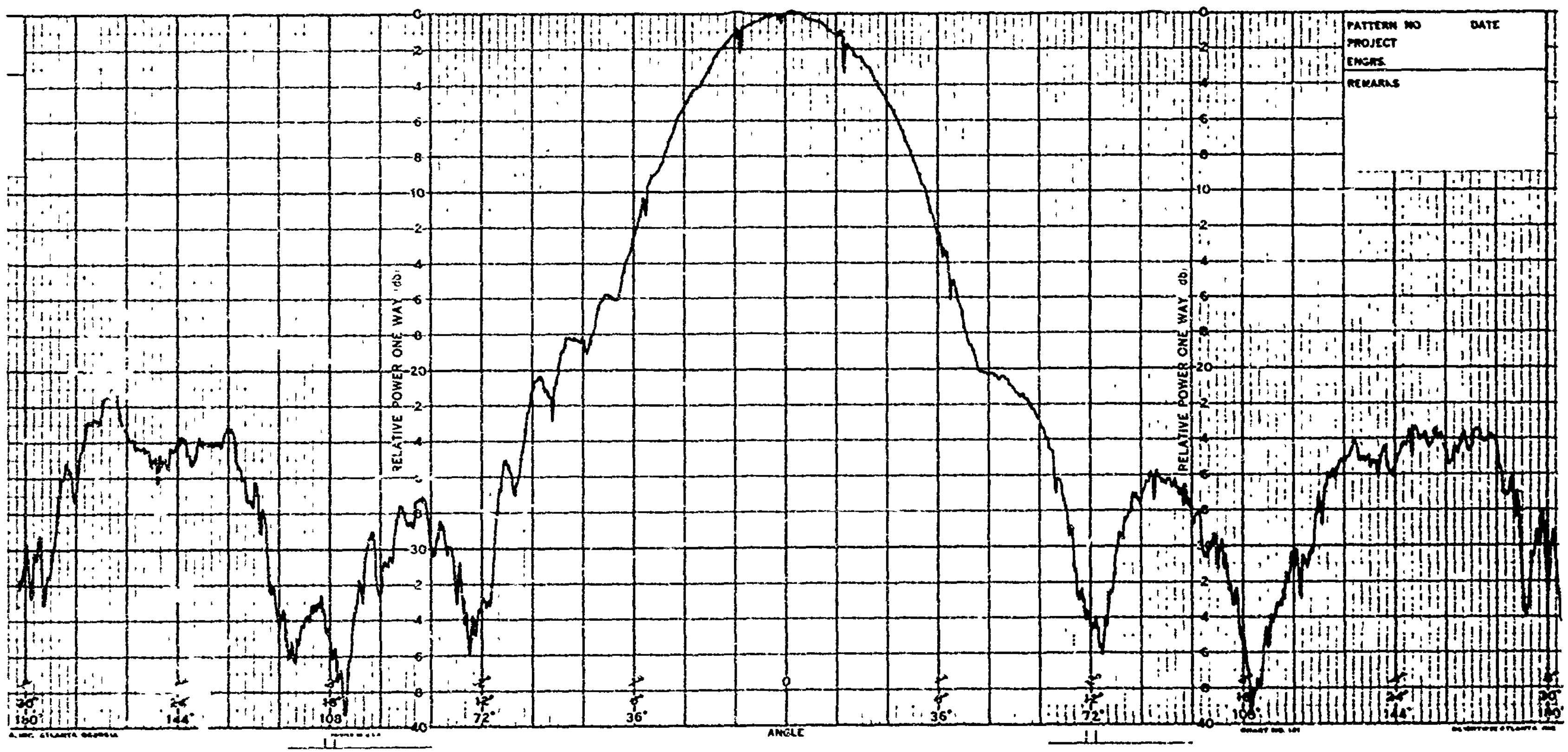


FIGURE 57. PATTERN OF THE UNMODIFIED HORN ANTENNA

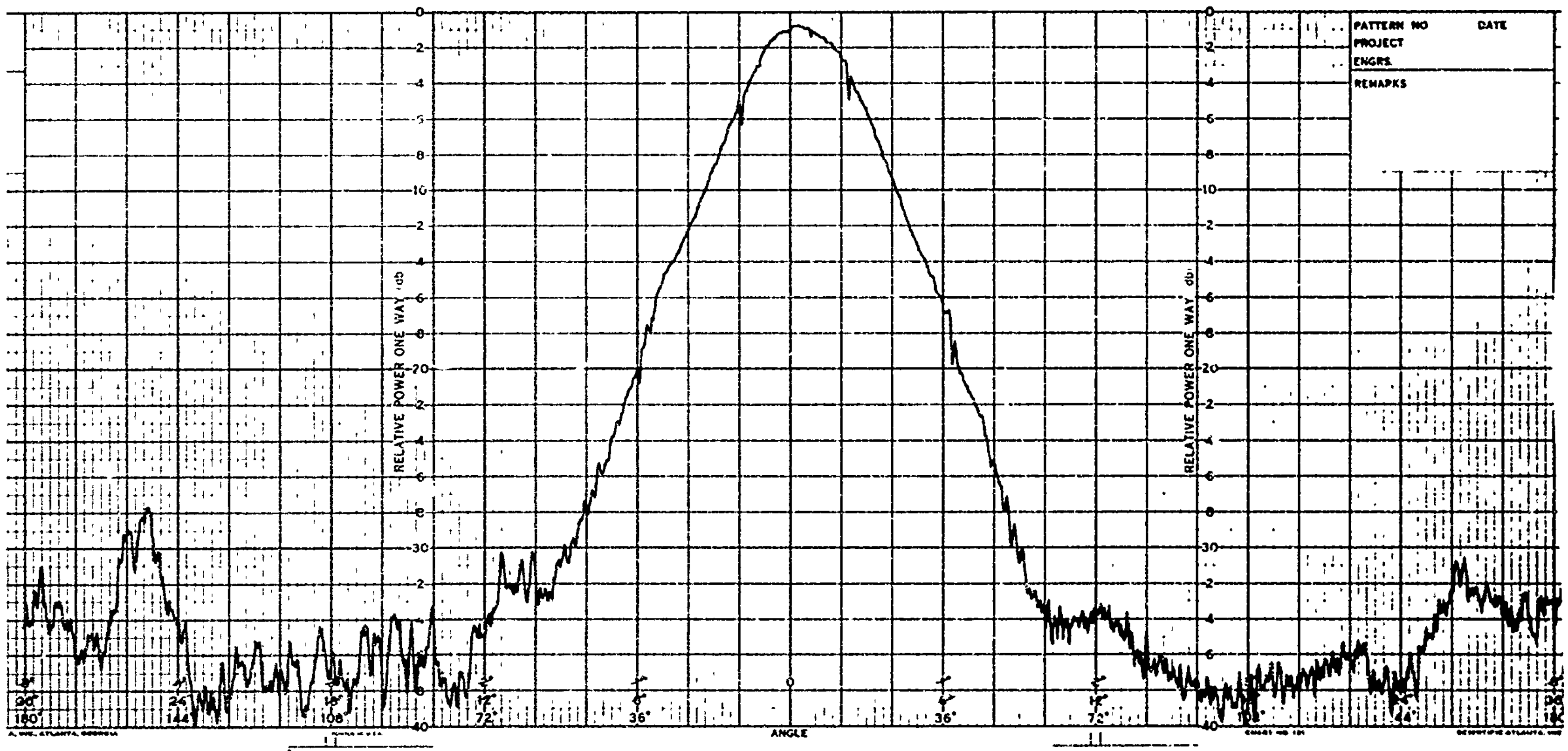
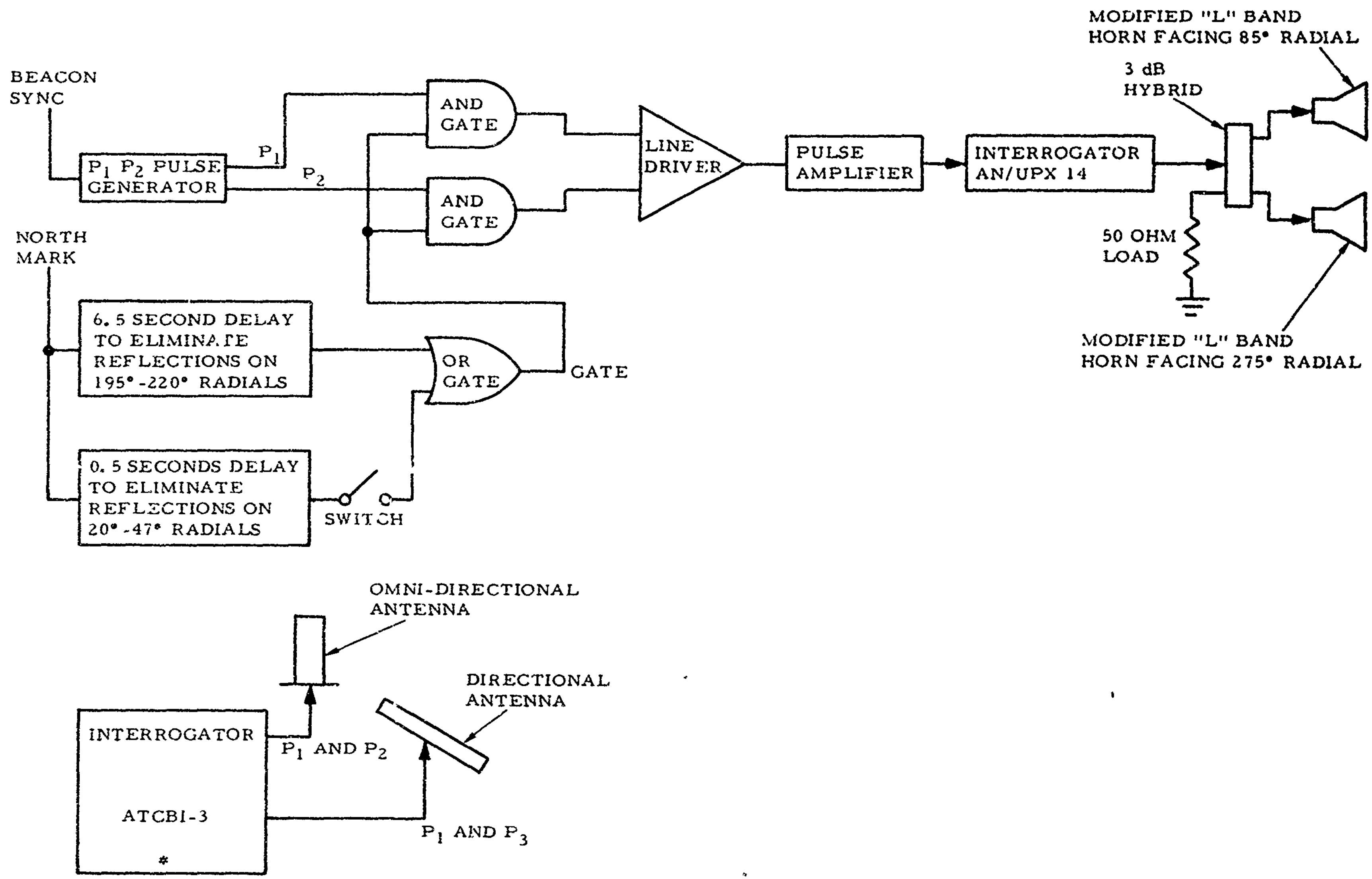


FIGURE 58. PATTERN OF THE MODIFIED HORN ANTENNA



* MODIFIED FOR IMPROVED 3 - PULSE S. L. S. SYSTEM

FIGURE 59. DIAGRAM OF HOW MODIFIED HORNS IMPROVE THE 3-PULSE SLS SYSTEM

Figure 59 also shows the logic circuitry that was used to generate the P_1 and P_2 pulses associated with the AN/UPX-14 Interrogator. A more detailed break-down of the logic circuitry pulse amplifier and circuit waveforms is shown in Figure 60.

Horns On/Off.

Synchronization between the normal Improved 3-Pulse SLS System and the NAFEC modification logic circuitry was provided by the ATCBI-3 interrogator "beacon sync" pulse. The beacon sync pulse was delayed by the logic circuitry to produce P_1 and P_2 pulses which were in synchronization with the P_1 and P_2 pulses generated by the ATCBI-3 interrogator. The P_1 and P_2 pulses generated by the logic circuitry were then gated on and off by special gating circuitry so that P_1 and P_2 pulses were radiated from the horn antennas only when the rotating directional antenna was pointing at the reflecting surfaces. Gating of the P_1 and P_2 pulses radiated from the horn antenna was necessary to prevent excessive suppression of the aircraft transponders flying on the Trevose radials of 85 and 275 degrees. Excessive suppression of transponders would have occurred if the radiation from the horn antennas was continuous, similar to the normal Improved 3-Pulse SLS System radiated from the omni-directional antenna.

Gates 1-second in duration, (this could be done with Improved SLS) were used to gate on the P_1 and P_2 pulses in the logic circuitry. The circuitry which generated these gates was triggered by the "North Mark" which, in turn, was developed by the antenna pedestal. The North Mark from the pedestal was delayed using the Honeywell 3C Logic Module DM-336 Adjustable Delay Multivibrators, shown in Figure 60. The adjustable delay multivibrators were used to control the start of the 1-second gates relative to the North Mark. In this way, the occurrence of the gate could be varied so that it coincided with the antenna rotation time when the directional antenna was pointing at the reflecting surface (the azimuth on which the reflected replies occurred).

A 6.5-second delay was used to gate on the P_1 and P_2 pulses. For 1-second, to eliminate reflected replies which occurred in the Salisbury, Maryland, area (205 degrees), and a .5 second delay was used to gate on the P_1 and P_2 pulses, for 1 second, to eliminate reflected replies which occurred at an azimuth of approximately 23-45 degrees. A switch was provided in the circuit which was used to eliminate reflected replies which occurred at an azimuth of approximately 23-45 degrees. The switch was installed so that the circuitry could be switchboard in if required, but at the time that this report was written, the switch was left in the "off" position at the Trevose Site.

The Improved 3-Pulse SLS System modification, as designed by NAFEC, was incorporated into the Trevose Radar Beacon System and evaluated by the Eastern Region under actual operational conditions. The initial evaluation tests were conducted using an obsolete AN/UPX-6 interrogator which was eventually replaced by the newer AN/UPX-14 interrogator, which

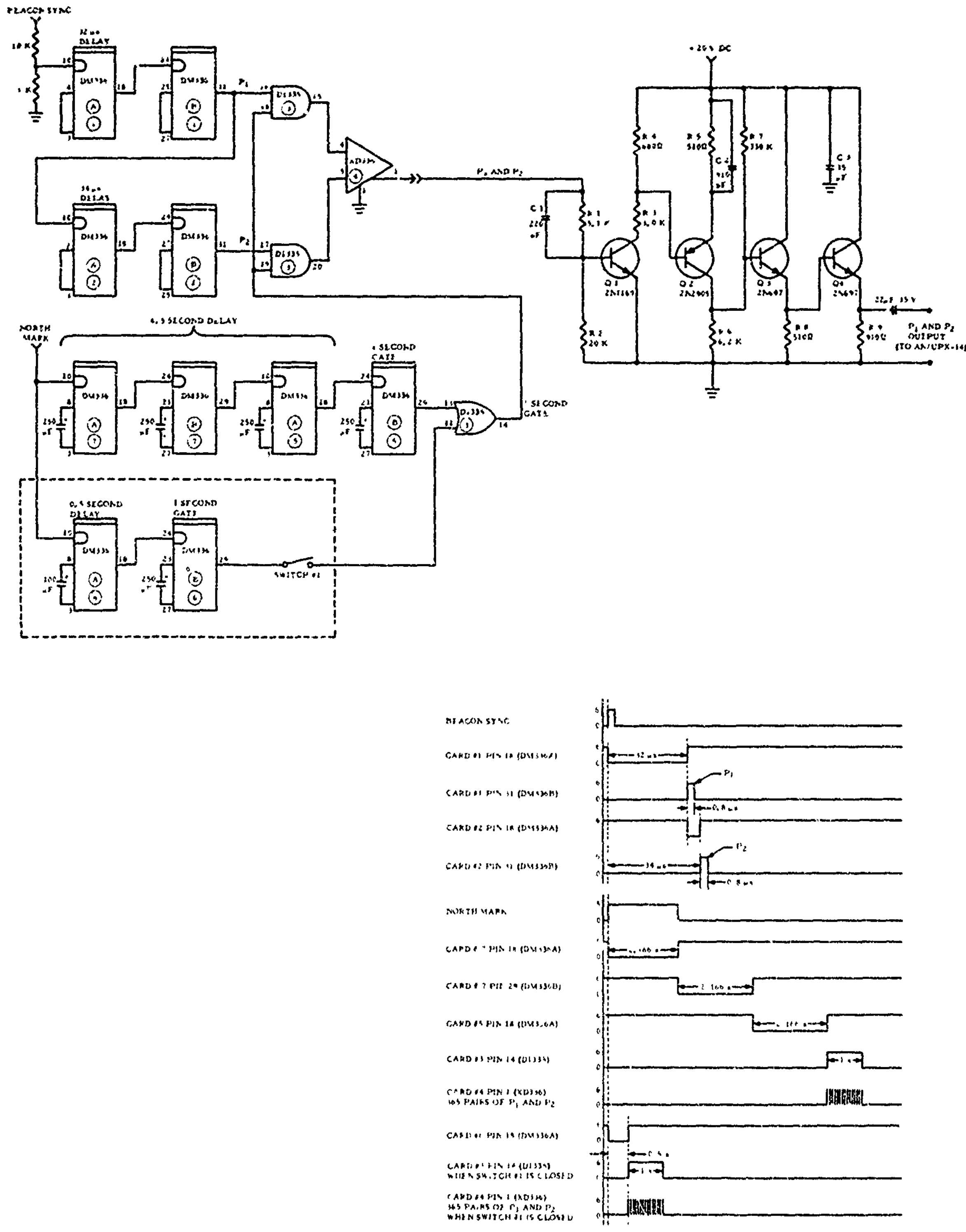


FIGURE 60. THE HONEYWELL 3C LOGIC MODULE DM-336 ADJUSTABLE DELAY MULTIVIBRATORS

is presently installed. After more than 5 months of evaluation testing, utilizing the AN/UPX-14 interrogator, the NAFEC modification was determined to be capable of performing the functions of eliminating the reflected radar beacon replies without compromising the air traffic control radar beacon system operational performance.

The results of the evaluation tests that were performed at the Trevose En Route Radar Site, indicate that:

1. The high-gain horn antenna is an effective fix in eliminating reflected radar beacon replies when the reflected replies occurred over narrow azimuths and at ranges beyond the normal range of the Improved 3-Pulse SLS System, and

2. The use of a horn antenna, to radiate the Improved SLS System radiations, eliminated the need for erecting a screening fence, adjacent to the radar site, to eliminate the reflection of radar beacon signals from the surface of near-by buildings.

McCook Problem.

In August of 1971, a request was received from the Great Lakes Region for NAFEC assistance in the investigation of reflected beacon replies at the McCook, Illinois, En Route Site. NAFEC aircraft N-376 was flown to the vicinity of the McCook Site and preliminary flight tests were conducted in the area. Numerous reflected beacon replies were observed, during the flight tests, due to reflections from buildings in the vicinity of the En Route Site (Figure 61).

Part of our investigation of the McCook Site included examining the radar beacon interrogator and receiver parameters. During our examination of the McCook ATCBI-3 Interrogator, problems were uncovered on the diode switch of the Channel 2 interrogator. The omni-directional antenna output of the Channel 1 interrogator also measured much lower than the directional antenna power. Since the omni-directional antenna radiation plays such an important role in the elimination of reflected beacon replies, it was decided that a reassessment of the McCook reflection problem be made by the Air Traffic Controllers at the Aurora Center.

Just about this time, the Whitehouse, Florida, coverage problem was presented to NAFEC. So far, we have not been able to return to the McCook En Route Site to complete the investigation of the McCook Site that had been started. But we do intend to return if we are still needed.

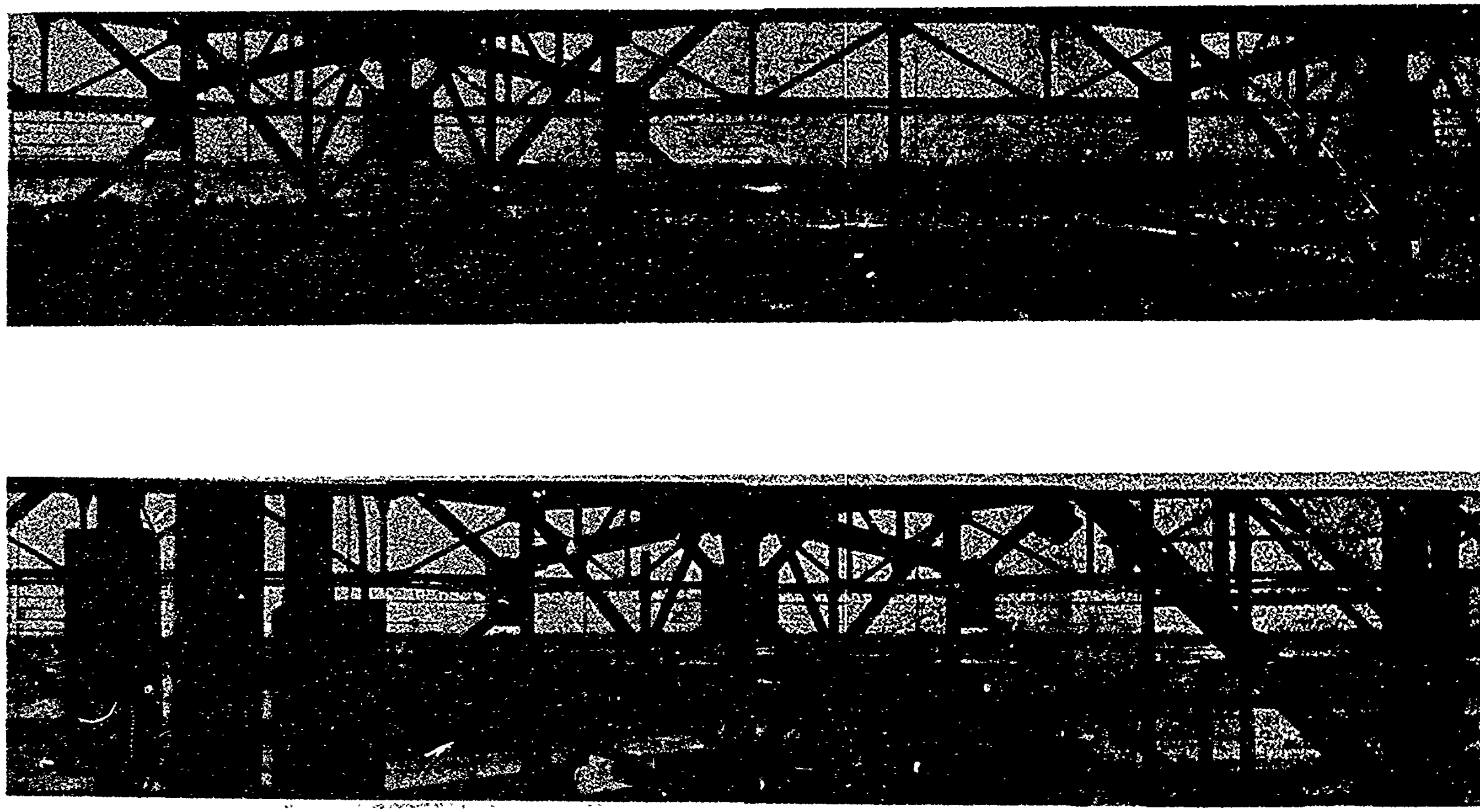


FIGURE 61. THE McCOOK, ILLINOIS, EN ROUTE SITE

FIXING THE TREVOSE SITE

by Arnold Beller, EA-432 (19)

I would like to thank all the people at NAFEC in general for developing the fix for Trevose, and for giving our air traffic people a system that is usable at this point.

Trevose Information.

The only addition to the speech that Mr. Spingler made, that I'd like to make is about the horns that were installed in the sectors where we wanted to get our omni signals, P_1 and P_2, SLS power out. Originally we just had our horns installed there, and we noticed some suppression of targets around the antenna. Basically that was one of the reasons for going to the extension of the horns.

There are railways that come within 10 to 15 miles of the site and around Yardley and Woodstown to Robinsville, where, when the horns were fired, there was a short track there where the targets would weaken and get some breakup. After the extension of the horns, which reduced the side lobes considerably, this was practically eliminated. I'd just like to add this side-comment to that part of Mr. Spinglers talk.

In addition the power in the horns was reduced to the amount just required to do the job, so there wouldn't be any more suppression of the targets, out in the areas beyond our concern, with other radars in the Benton system and the JFK system, and try to keep down any suppression that was out there.

Some of you were interested in how the region solicited the assistance from the Washington office and NAFEC to help us resolve the problem.

Trevose Background.

A little background on Trevose. It was really a replacement for the Palermo radar, which was a joint use site that was located on the coast of Southern New Jersey. This site was subject to a lot of angel activity, and airways that come right over the site, which presented a control problem because of the size of the targets as they came in towards the apex, and also the clutter buildup near the site. Another problem was the amount of traffic in the area, and the pulse width of the FTS 60-20 series radar was too wide for their operation. These were some of the things instrumental in seeking a new site.

In addition, Gibbsborough was supposed to be a replacement for Palermo, but the Gibbsborough system was not acceptable because it was an S-band as far as tracking and weather. There was no weather fix there close to the site. The Gibbsborough facility didn't work out as expected.

We went to NAFEC again for help, and they requested that Elwood be used as a site until a new site to replace Palermo was made. This was done. At this time the military was phasing down and a number of FPS-60 series radars were made available to the FAA. These were modified by R&D, Washington, and made acceptable for air traffic, and we got the funds for a new site.

Site selection is limited to certain locations. You've got to have overlapping coverage with existing radars, you have to try to meet the requirements for air traffic, and you need suitably priced property for site location. To get an ideal site is almost an impossibility within all the various parameters, including equipment parameters.

Only two sites were found suitable for replacement of Palermo; these were North Philadelphia and around McGuire Air Force Base.

Siting Criteria.

The prime consideration for selecting Trevose was the operational airway structure at the time. At that time one of the factors for selecting the North Philadelphia area was to have the radar outside the area where they were going to control traffic, and the site would not be in any of the sectors where Trevose was going to be used.

This was reviewed by many levels. Information on the beacon siting was very sketchy at the time. In addition, the primary radar requirements need also be satisfied besides the secondary radar requirements. There are still sectors in the lower altitude that operate on primary radar.

When the siting selection for Trevose was made in 1969, there was and is a lack of proper siting criteria, although ideal siting criteria may never be met in the real environment.

Incidentally, the document that transmitted Mr. Spingler's Trevose siting report was sent to the regions only on top level; it never got really down to the working level. When we were made aware that this document was available, the Eastern region had 200 copies of the document produced, and as directed, went out in the field to all the radar facilities, making them aware of the problems, and siting criteria, and the effect that new construction could have on a facility, and actions to take to try to alleviate it, and if they couldn't prevent it, to change the environment as explained in the report (actually, we did this at Saratoga Springs, which was quite successful).

Once the decision was made to place the radar at Trevose, there was really no turning back because land condemnation was started. The owner was quite peeved at the FAA. He had other plans for the land.

The FPS-60 radar was modified by Bendix to make the system more or less comparable to an ARTS type system, where the receiving system was completely modified, and the objection of wide pulse width FPS-60 series

of 6 microseconds was reduced to 3, and even the 3 microsecond pulse is still a little problem for the air traffic controllers in separating traffic.

Actually the facility was flight checked at the site. The people who were doing the flight check could not at the time recognize that they had any reflections; not knowing what each aircraft was, and not having information on the aircraft in the area there. It was very difficult to tell whether you had a reflection or not, and what they were interested in at the time during the flight check was one aircraft, and getting all the information for the commissioning.

Trevose Problems.

The facility was commissioned on November 9, 1970. As soon as it was fed into the center it was immediately recognized that there was a major problem as far as the beacon ghosts were concerned. The system at that time had SLS equipment on it, and the panic button was already pushed, and FIS was already contacted to get an SLS immediately, and this was transferred immediately from another facility and installed on November 11. Some improvement was noted but not enough to have an acceptable system.

Washington was aware of the problems from the NASCOM, telephone calls from our F and E people, and also from the impact these problems had on traffic control. The call was made to RD 200 for NAFEC assistance, followed up by a teletype, and within one day, or a few days, Mr. Spingler and his crew were out at the site investigating the problem in the site and also at the center.

The installation of what we call the de-ghosters was actually completed the 23rd of February. But this didn't solve all the problems. There are still other areas of reflections, but they are not as serious as those in the Salisbury area, where these ghosts targets came up right on the airway with the real targets. They wouldn't show up for one or two sweeps but they would show up for 15 to 20 miles trailing the real targets there.

New Antenna Fix.

Another problem was with beacon antenna lobing. What we did was to try to steepen the STC curve on the AT 309 antenna. This helped a little bit but we also started losing targets. Hank Bowen took patterns of the antenna; they looked normal. The only other thing we could do was to change the antenna, and with the assistance of Washington, we got the new FAA antenna, the FA 8043, in place of the AT 309. This was installed on April 1st, and there was much improvement on side lobing, and with a tighter adjustment on the GTC then they had at the time of commissioning, the side lobes are to a point where they are only rarely getting them now.

ANALYSIS OF REFLECTIONS AT THE COMMON DIGITIZER AND COMPUTER

By Vince Preston, AFS-22A (20)

Will Automation Solve Our Problems?

In the last few days we've heard a number of discussions that have touched on the automation - the ARTS II, the ARTS III, and the NAS Stage A, and it seems to be a general opinion that possibly the automation equipment is going to solve some of our problems. It reminds me of the story of a man who came home from work one day and he had his shirt sleeves rolled up, tie off to the side, collar open, coat over his shoulder, and his wife said, "Gee honey, did you have a tough time at the office?". He said, "Boy we sure did. At 10:00 o'clock this morning the computer broke down, and we spent this whole day thinking."

I think there is a lot to be said for that story. When the computer is broke down, we have to think the way we think now, in what we call the broad-band system. When the computer is working, we have to think in what we call the narrow-band system. And although a lot of the problems are common, the results, or presentations, differ considerably.

Broad-Band Versus Narrow-Band.

For those of you who are not familiar with the terms: when we speak of the broad-band system, we refer to the transmission of analog data from the radar site to our air route traffic control center using the radar microwave link. We are talking about a 14 megacycle band-width per channel. This is the broad-band system.

As the NAS Stage A becomes implemented we install more and more of the common digitizer, and now we transmit our data over telephone lines sending digital messages. The band-width of these telephone lines is only 3 kilocycles, so you can see there is quite a bit of difference, and we refer to this as the narrow-band system.

Figure 62 is an existing broad-band display, which is probably familiar to you, and it represents one sector at Jacksonville Center, Sector R-36.

On the right hand side, on the lower part is the location of the Jacksonville radar (JAX) site, or the Whitehouse radar, as it is now called, since we've moved the site. And to the left is another radar site, the Valdosta radar (VAD). When we're operating in the broad-band operation, this particular sector, R-36, receives its video from the JAX radar, and as you can see, the four aircraft look real good. You might notice that this area is almost equally spaced between VAD and JAX.

Figure 63 represents the same sector, R-36, using the narrow-band presentation, VAD and JAX.

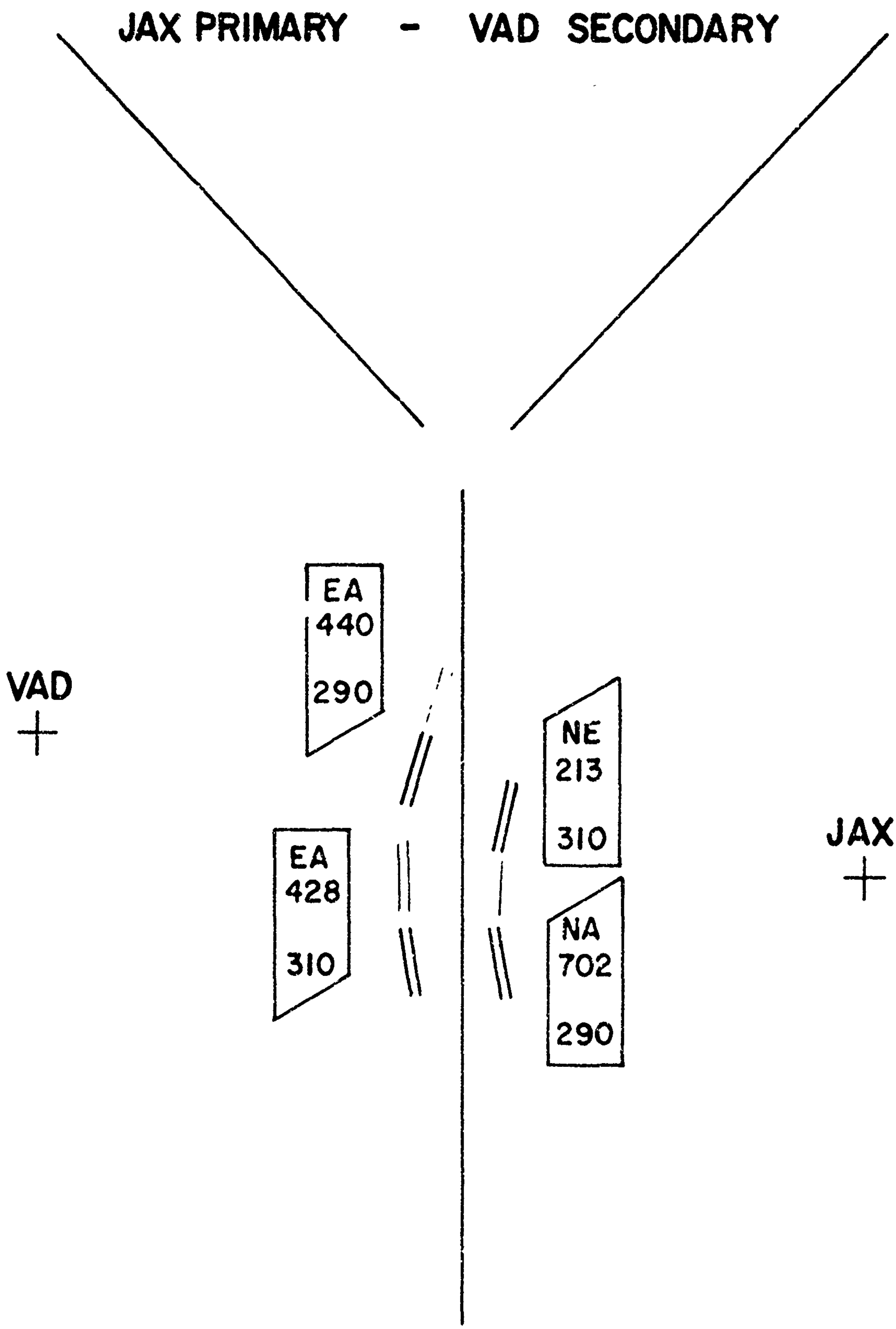


FIGURE 62. NG BROAD BAND DISPLAY AT JAX SECTOR R-36

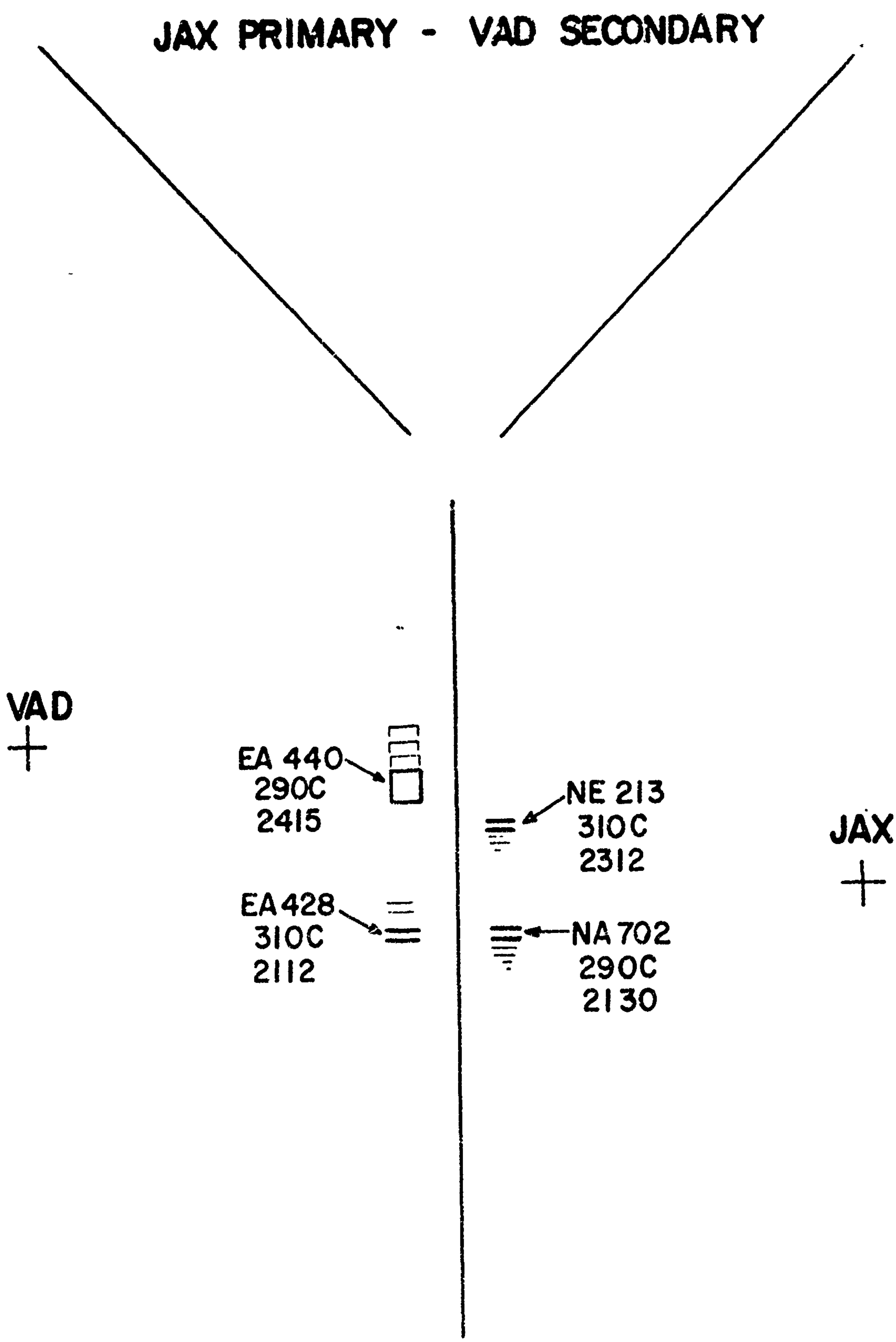


FIGURE 63. NARROW BAND DISPLAY, JAX, R-36

Unfortunately, Whitehouse radar is not presently commissioned in the narrow-band system. It is commissioned in the broad-band system, and that is why P-36 is using it in the broad-band. But in the narrow-band system, we're making use of the VAD radar, and we're providing the narrow-band information to this same geographical area.

Double Slash Versus Symbol.

In the narrow-band system at JAX, we represent discrete beacons or selection beacons with either a double slash symbol, and this is not the same double slash that your used to seeing in the broad-band system, this is actually a symbol generated by what we call a data filter group, and its a fixed size symbol, not growing larger the farther from the Vortex, or the controller has another option of representing a box as a symbol depending on the filtering instructions he gives.

We've got a little data block running along with the symbol. In this case there is Eastern 440, he's at 29,000 feet, he's been Mode C verified, and his beacon Mode C code is 2445.

Same Old Problems.

I'm not going to get into a lot of detail about the problems that we have with the narrow-band presentation, but there are many problems in this type of presentation, and as we investigate them we find out that they are caused by our old friends - beacon reflections, beacon false targets, and beacon splits. But they show up quite differently in a narrow-band system.

Radar Mosaicing.

This feature that we have of presenting VAD data to normally JAX scan converters is what we call radar mosaicing, and its a common function of the NAS program. We can bring in 2, 3 or 4 radars, having overlapping coverage, and they can use the data from either one for a particular geographical area.

This particular geographical area normally JAX is considered the primary radar and VAD the secondary radar, but since JAX is not in the NAS system, the Whitehouse radar, then we're picking up the data from VAD as I said.

The reason I selected R-36 to discuss the problems that we have been discussing today is because that 110 degrees off the VAD site is our old friend the RML tower at the radar site. And it just so happens that in the narrow-band system, when we're using VAD to provide the data in this area, we have a real serious problem of false targets, ghosting, and splits. If we were able to go back to the broad-band JAX system the problem disappeared because there was no longer any reflections in this area.

Figure 64 represents the flight of a 727 on code 2115, flying at 31,000 feet, 480 knots, from Spartenberg to Tampa, on December 28, 1971. This is a computer reproduction of the narrow-band data that the VAD site was providing us, and if we follow the flight from the North we find the "R", which is the real target, descending very nicely, and suddenly when he gets into this area here we pick up a split, and that is what the "S" represents. He goes a little farther South and "R" represents the real target. We look down near the 111 degree radial and find "G^1," a ghost target at the same range, close to the azimuth of the RML tower.

Computer Finds the Problem.

As we go a little further we get a true target R^2, and we look the 111 radial and find a ghost G^2, R^3 and G^3, R^4 and G^4, R^5 and G^5, you can see its very consistent, very obvious, R^6 and G^6. Then we get into an area where there is some real bad splitting, and then our real targets look pretty good for a while, and then we get this splitting and ghosting again.

This problem became very evident when we began to get into the mass computer operation. We had been operating the VAD radar since approximately 1961 in Jacksonville and unfortunately we never realized we had a problem. So that's one of the reasons that I said in the beginning that you have to change your thinking a little bit with the computer and when you are without the computer. Of course the problem was always there, it just wasn't very obvious in the broad-band system.

This data of this one particular flight just happened to be a target of opportunity flying through the Jacksonville area, and this represents what we can do with the NAS Stage A computer with what we call the data reduction analysis programs. I want to talk about that. I know the representative from New York discussed some programs they are using in the common IFR room.

Data Reduction Analysis Programs.

The NAS system has been designed with many of these processing programs that can look at radar data and tell us a lot about it. For example, this particular plot was done manually on a computer printout. We asked for a reduction for a discrete target on code 2112 and we got pages and pages of range azimuth and other data on this one particular target.

Figure 65 is a compressed picture of what the printouts look like. The top line is the heading. The "B" says that this was a beacon message from a common digitizer. The "C" tells us whether or not he was Mode C validated. The "3" tells us he was mode 3 validated. The "D" says that he was a discrete target, or one of the 4096 codes. The "R" says that he was radar reinforced. His range is given in nautical miles. His azimuth in degrees. There is also an ACP on the actual printout. The mode 3 code, the mode C reported altitude, and the time from the last message that was printed out on this particular printout. Now the VAD radar works on a nine second scan, and we would expect to see somewhere around nine seconds showing on the printout.

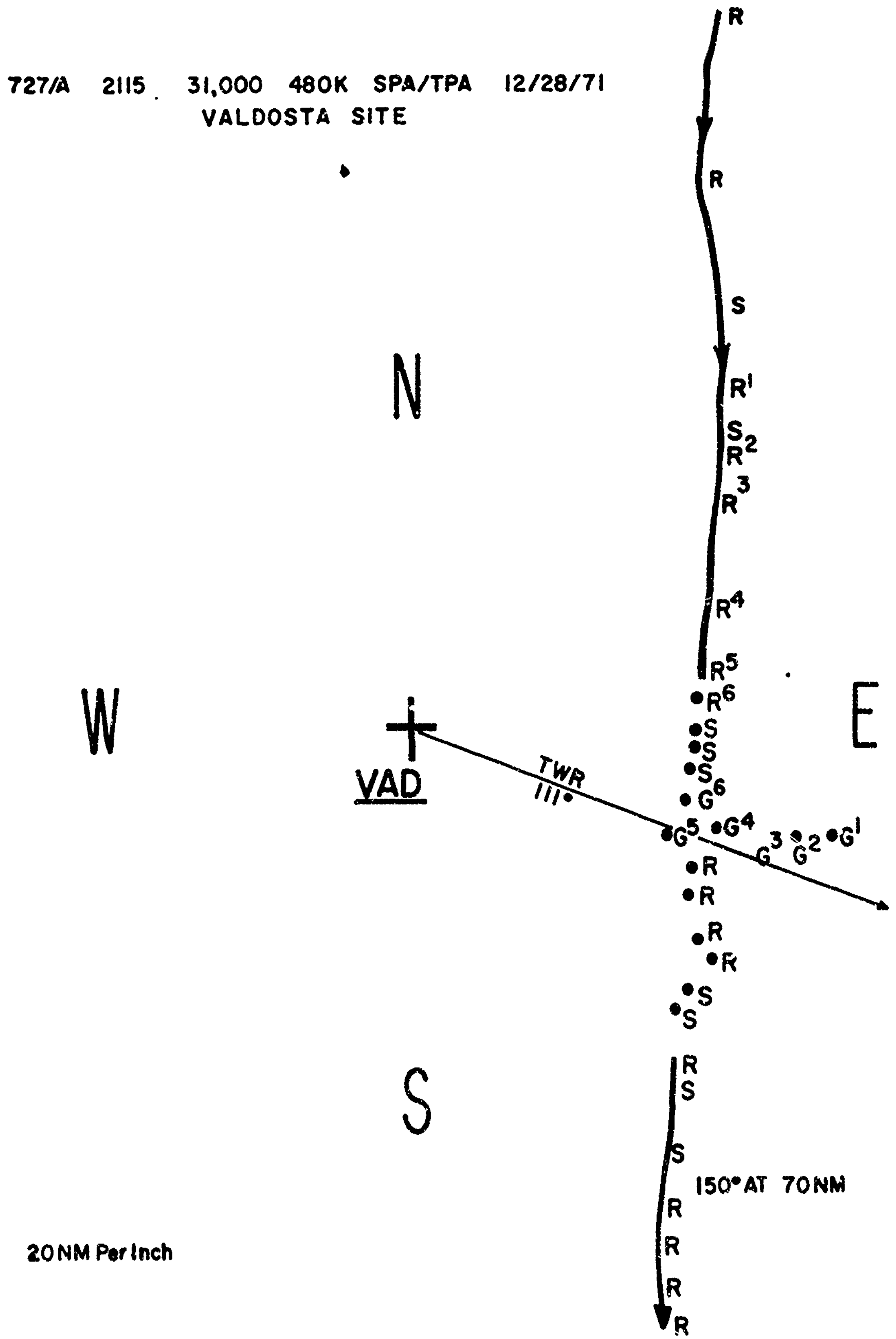


FIGURE 64. REPRESENTATION OF A FLIGHT (R = REAL TARGET, S = SPLIT TARGET, G = GHOST)

BC3	DR	N.M.	DEG.	MODE	ALT.	TIME
BC3	D	98.3	20.318	2112	33700	9.0
BC3	DR	99.1	22.421	2112	33700	9.1
BC3	DR	100	23.572	2112	33700	9.0
BC3	D	100.2	160.891	2112	33700	3.1
BC3	DR	102.0	25.141	2112	33700	6.0
BC3	DR	104.1	27.163	2112	33700	9.0
BC3	DR	106.3	29.271	2112	33700	9.0
BC3	D	106.4	32.678	2112	33700	.1
BC3	D	107.2	31.246	2112	33700	8.9
BC3	DR	108.5	33.581	2112	33700	9.0

FIGURE 65. NAS STAGE A COMPUTER PRINTOUT FOR A DISCRETE TARGET

Reading the Printout.

If we look at this example, we can see some things of interest. If we look at the first line we see that this particular antenna scan is not radar reinforced; there is no "R". We drop down further, we see this happen again. So we get a relative comparison here of the radar coverage to the beacon coverage. Plus, conversely, if we did have a radar presentation and no beacon we would not see that on this particular type of reduction.

He was at 98.3 nautical miles at 20.318 degrees, code 2112, and his mode C altitude was 33,700 as recorded by transponder, and this particular printout came nine seconds after the one before this one.

The second line looks normal. No problem. The third line looks normal. Now suddenly we find a time of 3.1 seconds. Well, we know the antenna didn't speed up. Something went wrong. Somehow 3.1 seconds after the last report of this target we have another report on him. Same code, and look at the degrees - 160 degrees - quite obviously this was a ghost.

It becomes very easy to find ghosts by just scanning down the right hand column, and finding these times. If you are not consistantly showing nine seconds, you've got a problem.

Six seconds later we pick up the true target again, and he's back to 25 degrees. Nine seconds later, another printout looks normal. Nine seconds later again, normal. All of a sudden .1 second later we get another printout. This is what we in Jacksonville refer to as a split.

There has been a lot of argument between everybody involved about these definitions - MITRE, IBM, the FAA - on what is a split, what is a ghost, what is a reflection. We refer to any real small range or deviation as a split. Then you have to sit down and say what is a small enough deviation and it requires definition. But for purposes of the Jacksonville talk we'd say that was a target split.

Eight point nine seconds we pick up a true target again, and nine seconds later another.

If you look at some of these actual printouts, the reduction of one flight running through the center, you see many splits, and many ghosts depending on where the aircraft is.

Options.

This particular data reduction program has many options. In this case we ask for a reduction only for code 2112, and we got all the data that the computer had for any aircraft on code 2112. Every message, every antenna scan that a beacon was received on 2112, we got a printout on it.

We could have requested all beacons, and if you have a lot of high speed printer paper you can use it up real quick, because every antenna scan, every beacon target that comes in will get a printout on it.

We could have asked for all search. We could have asked for beacon and search mixed, or we could have asked for a particular sector printout, and by sector I don't mean sector and center, I mean a wedge say from zero degrees to 15 degrees. We want all beacon information in that area on all search information. Or possibly we could ask for a ring, if we would like to know what is going on between 50 miles and 100 miles in 360 degrees of coverage, so we can ask for a ring printout.

This particular type of analysis is quite handy to the people in the center. In one days time we can look at all the radars coming in. We're recording the data on Ampex recorder right now, and we can reduce it any time - at night or any time we can get computer time. It takes an IBM 9020 Simplex - for those of you who are familiar with NAS talk, to reduce the data.

If you really want to get sophisticated and go a little further, there's another data reduction program called SIREAN, and its an acronym which means Site Registration Analysis and it'll take a particular flight like code 2112, and it will reduce and make a tape that can be used on a Calcom plotter here at NAFEC, and it'll give you an actual graphic or pictorial as we showed in Figure 64. It'll have all the printouts that we painted on that target, and the times of each printout, and these are very useful when we were trying to implement and get this NAS system off the ground to find out what kind of problems that we had with false targets and ghosts.

Types of Problems.

We ran a SIREAN program and some of these Calcom reductions and we were very surprised at some of the problems we had. The Jedberg radar had a terrible split problem - right at the azimuth 45 degrees of the RML tower. Whitehouse radar has got a problem in vertical lobing. The example in Figure 65 is a Valdosta problem.

The Valdosta problem is different from the Jedberg (Charleston, S.C.) problem. It's much different from Jedberg because Jedberg's has been isolated to the forty five degree radial, where the RML tower is. The Valdosta problem has been showing up in many different areas, and we're back to the fact that there is not only an RML tower at Valdosta but also communication towers surrounding the site.

Now the Southern Region feels awfully strongly about these RML towers, and they're getting $25,000 this month ready to remove one of them about 1000 feet from its present location. We'll see what effect this has at Jedberg.

The main thing that I wanted to bring up in this discussion is the fact that automation doesn't solve all our problems; in fact it brings some new ones along with it. But it does change the outlook, change your thinking on what is a problem.

If you're trying to run a double mode of operation like we are here at Jacksonville, in broad-band and narrow-band, you increased your problems by some number, you didn't solve them. But also the computer brought with it a new tool we've never had before. It allows the local people, in a very short amount of time, to analyse what type of coverage problems they have with the particular radar, or radars.

THE ADVANTAGES OF BEACON PERMANENT ECHOES

by Vince Preston, AFS-22A (20)

Today I would like to spend a few minutes talking to you about the installation and use of Beacon Permanent Echoes (BPE). As many of you know this subject has been an item of discussion for many years. Many field personnel have felt that the use of beacon permanent echoes for system alignment and certification would enhance existing procedures and in some cases provide capability that does not presently exist. Although there have been several isolated cases of facilities installing such devices for 1 or 2 radars, no large scale installation presently exists.

Beacon Permanent Echoes - What and Why.

Certainly, one should ask at this point just what is a beacon permanent echo and why is it desirable? I will attempt to answer these questions from the experience gained at Jacksonville Center operating with and without BPE's.

A beacon permanent echo is simply an aircraft transponder or similar functioning equipment installed at a fixed location within the antenna pattern of one or more beacon transponders. It is adjusted to respond to interrogations with a fixed mode 3 code (hopefully a national BPE code) and a fixed mode C altitude.

The immediate use of these transponders is quite obvious but many not so obvious and more sophisticated uses require deeper thought.

Immediate Use

The BPE provides a positively identifiable target that is neither obstructed by weather or clutter - a rather annoying disadvantage of search permanent echoes. The following uses are immediately available:

(1) It can be used by radar technicians to certify the range and azimuth accuracy of a beacon system from the actual radiated antenna pattern to the final display system.

(2) It can be used to verify system timing following a major failure or modification.

(3) It provides the radar controller with a full time indication of beacon system range, azimuth and decoding accuracy. Its use in this case as a confidence factor cannot be over emphasized.

(4) It provides the technician with a constant test target that can be used for troubleshooting purposes.

(5) It provides the technician and controller with a highly accurate fix-point to reference video mapper alignment accuracy.

(6) It provides the technician with a constant input for monitoring proper decoder and altitude readout operation.

Future Uses

As more and more of our beacon systems are interfaced with Common Digitizers and NAS Stage A computers, the use of BPE's could be greatly expanded. The following is a list of possible uses that is limited only by lack of large scale experience with BPE's:

(1) The Real Time Quality Control portion of the NAS Operational program could be written to make use of the BPE for:

(a) Registration Analysis - Present means of registration analysis require rather complex mathematic manipulations and software to verify system accuracy. The use of BPE's could eliminate this need by reverting to simple accuracy reporting monitoring.

(b) System Degradation - Since the BPE is a real target installed in the real world it responds to system degradation faster than test targets that are of the go/no go family. In addition go/no go test targets are usually generated somewhere after the antenna and in many cases, after the ATCRBS equipment.

(c) Display Accuracy - The NAS display program could be adapted to produce a digital reference symbol at the known location of the BPE. Each radar controller could then select the reference symbol and the actual symbol produced by the BPE. This would provide a positive, measurable indication to the individual controller that the beacon system he is using to control air traffic is providing accurate range/azimuth information to his display.

(d) Proper Decoding - Each antenna scan, the software could check the mode 3, mode 2 and mode C fields of the BPE to verify proper system decoding.

Certainly uses not mentioned above would be developed as more experience is gained with the Beacon Permanent Echoes.

Disadvantages of BPE

As with the implementation of any new system, certain problems should be expected.

(a) Reliability - Some critics have questioned the reliability of inexpensive aircraft transponders primarily due to their designed usage.

Although I will not attempt to defend this argument, I can state that with approximately 9 months of testing, using four transponders of this type, we have not experienced a single transponder failure in the Jacksonville area. Certainly if these devices were proven to be unreliable, a more desireable unit could be built to FAA specifications.

(b) Maintainability - The problem of training maintenance technicians and establishing supply support is also cited as a disadvantage to initiating a national program of BPE installations. I personally feel that this argument could have been applied to any new program such as TACANS, radars, and computer installation. In all of these uses the merit of need can only be measured by applying a cost versus benefits analysis. In the case of the BPE, costs can be sharply reduced by using centralized maintenance and repair and return techniques.

(c) Siting and Accessibility - Critics argue that necessary suitable points of installation do not presently exist and thus would require expensive leases or installation. Testing in the Jacksonville area has proven that simple installations at RML repeater sites and airport control towers are feasible and readily available.

The use of a helical antenna mounted on the RML building roof and aimed at the RML active or passive reflector has eliminated the need for difficult and costly installation on high towers.

SUMMARY

I would like to close this presentation by stating that the need for beacon permanent echoes is real and obvious. The only thing that is required to make them a reality is the support of all personnel that believe in their usefullness.

UNUSUAL PROBLEM AT THE NORTH PLATTE SITE

By Robert D. Cotey, DV-532A (21)

The North Platte, Nebraska, site has been a problem since it was installed in 1963, mostly to the East with targets splitting up, and also to the North.

The North Platte radar site is in the Central Region, and Central Region engineers installed a CPN 18 dipole antenna.

The primary radar is good, very few problems.

Dipole Antenna Fix.

The CPN 18 dipole antenna is bolted to the top of the feed-arm of the long range radar. I believe this is what they're experimenting with now at Whitehouse.

When we hooked up the CPN 18 we found that this area had good beacon. We have very few split targets. But another problem cropped up in the Northeast guadrant and also in the Northwest and West quadrants of the main bang. The targets would come across and they would be 30 or 40 miles long right out here; a very strange phenomenon. But elsewhere we would have no problem.

Some of the targets would also be splitting and some have some false lobes on the side. When the target was split the actual aircraft was always to the North if the split beacon.

I waited for United's DC-10 to come through, transponder equipped with the SLS feature. I thought maybe this would help us. But it doesn't look like he was any help for our particular problem. False lobes extend off this target also.

QUESTION: (Joe Scavullo) Is there anything you can say that is consistant about the target? Is the true target always the one that the antenna sweeps by first?

REPLY: Yes, that would be true. The sweep first hits the aircraft and then sweeps to the South and displays the long split beacon.

QUESTION: (Joe Scavullo) Are you acquainted with the site itself? Do you know what kind of obstructions they have there.

REPLY: The site itself is situated in the sand hills of Nebraska, and standing up on a 50 foot platform, you can look for 100 miles in every direction, it seems, and see nothing but jackrabbits and rolling hills.

In the Southeast quadrant you can look out and envision like a ballroom full of basketballs. These are the sand hills. They are very round shapes, and they'll extend as far as the eye can see. There are literally thousands of these hills, and they're all sand. Its just like a giant beach out there.

QUESTION: (John Kemper) Have you had the Central Region run an antenna plot out in that direction? An actual radiated antenna plot.

REPLY: No. Not to my knowledge. Not in the year and half I've been working with the problem here.

I know what you're all thinking, looking at this. It looks like our classical problem of extended side lobes, or typical ring-around problem, but, keep in mind, this is a occuring about 100 to 125 miles out.

Terrain Factor

The first thing we suspected was that it was a bad beacon antenna, and over the period of the last 7 years that this problem has been worked on, the beacon antenna has been both patterned and changed. We did run the van out there. We did run a pattern analysis on it. We did find the side lobes to be within tolerance. So we pretty well ruled out the fact that it was side lobes. We definitely feel that the ground terrain has been a contributing factor, because when we went to the integral feed antenna, the CPN 18 dipole thing, with the sharper low angle cutoff. It did result in some changes to the symptons. As he mentioned, it didn't completely cure the problem, because it shifted it to another quadrant, but it did give indications to us that the problem is basically one of ground reflections of some type, and we're not sure just exactly what's happening with this very unusual terrain that's out there.

The radar chief at the site recommends that we just dig the site up and haul it away to some other spot. Instead I saw on the schedule on ARSR-3's that we're destined for a radar site here at Hastings Nebraska. From this proposed site, due to problem areas about the same distance here as our Platte if we could have some priorities established for building this site, we could surely use the radar digitizer here and get a much better picture than we have now.

We have actually two other sites that are within about the same range here as North Platte. We have the Garden City radar, and Hutchinson.

Kansas City at one time had this air space, and we inherited it about 1964.

Omni Power.

The latest efforts made out there are very interesting. What the people have done is a rather unique recabling of the transmitter in such a way that the signals feeding the directional antenna are being processed through only

3 cavities of the four cavity system, whereas the signals feeding the omni antenna, the P_{-2}, P-1 combination are actually being
antenna, the P-2, P-1 combination are actually being power jacked up on them by going through the fourth power cavity. So what they have done is to significantly increase the omni power. Its my understanding that this has resulted in some improvement.

We did like the CPN 18 dipole because it did display a very narrow target, instead of a long wide target. It's easy to separate aircraft when you have a small target like that.

Sixty-Mile Target.

They disabled the ISLS feature at North Platte also, and bypassed that. When they did hook up the ISLS, for some reason between Helsini and Goodland Kansas, we had very bad beacons, they rang for probably 50 to 60 miles long, and it was very disheartening to see that. We disabled that ISLS and went back to normal beacon, but the minute they entered this area they showed up like, so, splitting down real far.

COMMENT: (Joe Herrmann). You've got a problem which is the reverse of what Whitehouse is experiencing. We're losing targets and we're trying a Rube Goldberg down at Whitehouse, that may or may not work for you, but its worth considering at your site.

At Whitehouse we're putting up the dipole antennas, having the 28-foot antenna, putting 2 interrogators, and 2 receivers in parallel. So when one antenna loses target, hopefully the other antenna still sees him. We sum the videos, and hope to fill in the holes.

You might try the same scheme in reverse at North Platte. Put your dipoles back up again and put another antenna upon the dipoles and run both antennas together, and use the dipoles for your stuff from 50 miles out, and just gate the 28-foot antenna on for the loss in stuff for high angle coverage. That's worth thinking about, and it possibly would work until we get Marty Natchipolski's E-scan antenna out there, which I'm sure would solve your problem.

You've got a ground reflection problem which is rather unique, and I think on E-scan antenna would make your system look good, but in the meantime think about the nutty thing I just mentioned.

The central region engineers told me if we had a fence 80 feet high out there we could reduce these split beacon problems; of course, that's unrealistic.*

*NOTE: An antenna fix for the North Platte ATCRBS was completed and installed by NAFEC, ANA-120, in June 1972. The problem was reflections from ground terrain. A report is forthcoming.

SECRA ISLS
FALSE TARGET SUPPRESSION CAPABILITY CURVES

By Robert J. Stutzman, SW-432 (22)

The curves in Figure 66 were developed in the Southwest Region to be used as a tool in determining when we could expect the ISLS feature to suppress false targets in terms of reflector orientation and radar site to reflector distance. They were derived using the principles outlined in report NA-69-36 by Mr. George F. Spingler, where he developed a method for determining the location and orientation of a reflecting surface by use of an ellipse.

The criterion tested is the requirement for a minimum 2-microsecond delay between the direct omni pulses and the reflected directional pulses at the aircraft, to initiate transponder suppression action. If the curves indicate that this criterion is not met for any particular case, we are assured that the resulting false targets cannot be suppressed with the ISLS feature. Conversely, if the curves indicate that this criterion is met, we can proceed with the testing of the remaining ISLS system criteria to determine if false target suppression will occur.

The individual curves represent the points where the 2-microsecond delay is achieved for a particular reflector incident angle. For any selected radar site to reflector distance, false targets can be expected to a range where the appropriate reflector incident angle curve is intercepted. The lower end of each curve is approaching the horizontal; therefore, if a radar-site-to-reflector distance is selected which extends below this horizontal point, the 2-microsecond delay is never achieved, and false target suppression cannot occur at any range. The upper end of each curve should be extended vertically to determine the intersection point for the longer radar site to reflector distances.

It should be emphasized that false targets cannot be suppressed under any conditions at very close ranges. These close-in false targets can begin at a range equal to the radar site to reflector distance and extend to the range indicated at the intersection point of the appropriate reflector incident angle curve.

An interesting observation from these curves is that for any reflector incident angle less than 46°, the 2-microsecond criteria cannot be met and the ISLS feature will not work. This is a useful preliminary check when analyzing existing false targets. An approximation of the reflector incident angle can be obtained by noting the azimuth angle on a PPI, between the true target and the false target. The approximate reflector incident angle will be one-half of this observed angle.

Most structures contain reflecting surfaces at right angles to each other, and except for the 90-degree incident angle case, both surfaces are exposed to the SECRA antenna. Only one surface can be oriented for effective suppression by the ISLS feature. Elimination of false targets caused by the remaining surface must be accomplished by other methods.

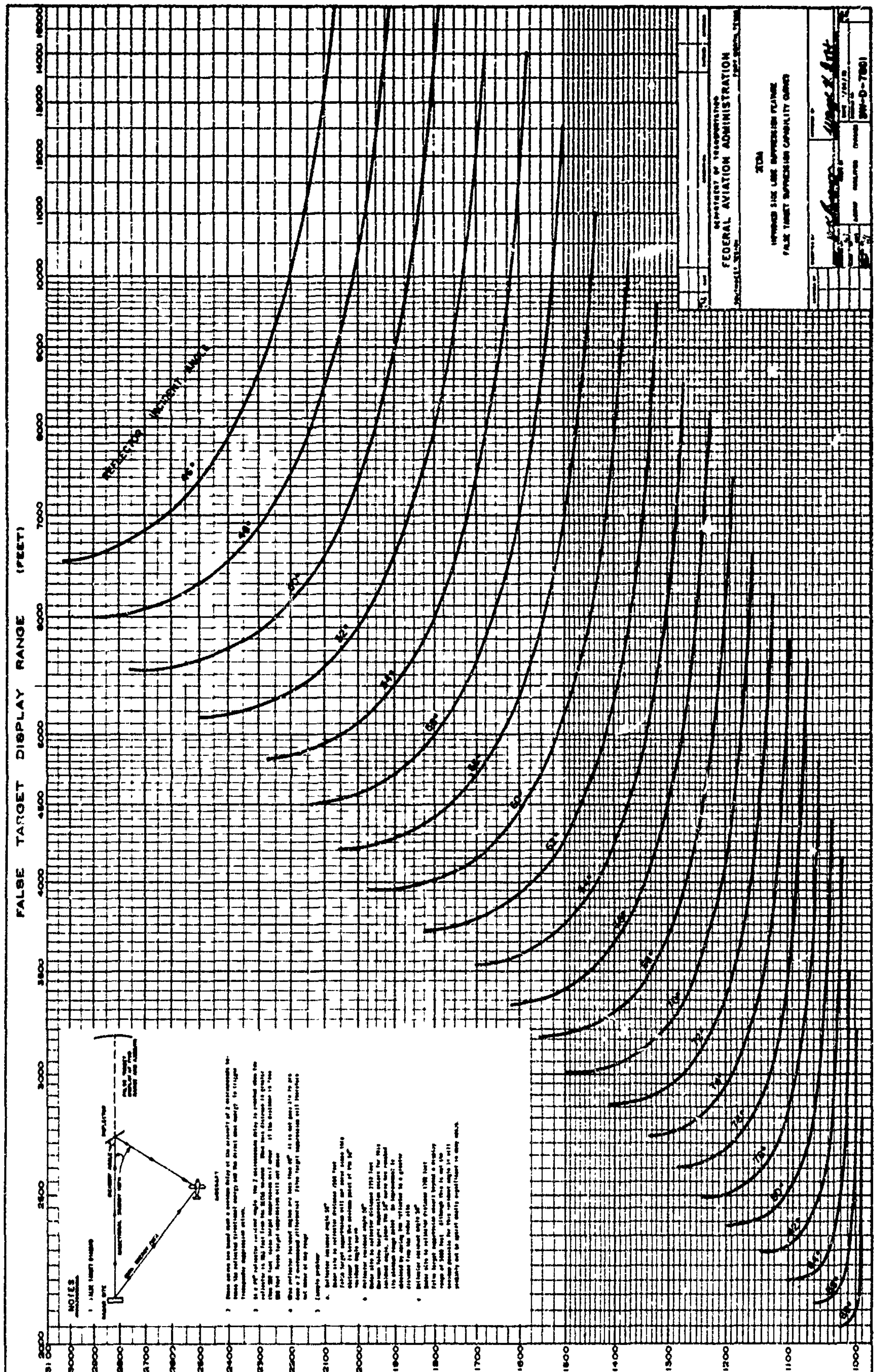


FIGURE 66. SECRA ISLS FALSE TARGET SUPPRESSION CAPABILITY CURVES

In conclusion, these curves have proven to be an aid in the evaluation of the operating limits of the ISLS feature. They indicate that many false targets can be suppressed by the ISLS technique. However, if we are to achieve the degree of freedom from SECRA false targets required by our facilities, other existing fixes must be employed and new fixes developed.

MISSING TARGETS AND FADING WORKSHOP

PROBLEMS OF MISSING AND FADING TARGETS

By Thurman L. Duncan, RD-242 (23)

Air Traffic Control Radar Beacon System

The ATCRBS is comprised of airborne transponders in cooperative aircraft which are interrogated from the ground based interrogator system. An aircraft's position, identity, and altitude are determined from the airborne replies to these interrogations by various types of decoding, automatic processing, and display devices. The basic design of the ATCRBS is such that if all the airborne and ground components in the system are operated and maintained to the characteristics and tolerances set forth in the U. S. National standard for the IFF Mark x (SIF)/ATCRBS, we could reasonably expect to obtain continuous surveillance of all cooperating aircraft within the coverage area of any one ground based interrogator system, such as terminal or long range radar. Our experience with the system, however, has shown that continuous surveillance is not being obtained. We have the problem of targets fading and of being missed entirely. It is, therefore, on the subject of missing and fading targets that we will concentrate on this afternoon.

Definition of a Missed Target and Fading

Essentially a missed target is one that doesn't get through the system, either because the aircraft didn't receive or respond to the interrogation, or it's reply didn't overcome the ground system thresholds.

Fading on the other hand will result only when the strongest signal from the interrogator reaches the airborne antenna, while missing hits on the leading and trailing edge of the run-length of the target. Fading will range from a slight narrowing of the target to where only one or two hits are registered or a complete miss.

Fading should not be confused with broken targets, where hits are missing in the middle of the run-length which are caused by other system problems. This is not to say, however, that some target break-up may be due to instantaneous fades that can occur when the ground antenna beam is distorted during its sweep across the target by the aircraft configuration.

A Missed Target. A target that fails to exceed the threshold for detection by either an operator viewing a manual type PPI Display, or an automatic processor such as in NAS Stage A or ARTS is a missed target.

Fading. A target that becomes narrow on a manual PPI Display due to missed hits on the leading and trailing edges is a fading target.

Causes of Missed and Fading Targets

Various factors can contribute to missed and fading targets. If the airborne equipment is malfunctioning, such as a transponder that has low

sensitivity or low power output, difficulty may be experienced in interrogating the aircraft and receiving his replies. However, this type of problem may be easy to spot if a comparison can be made between this target and others on the same display. A malfunctioning interrogator can likewise cause targets to fade, or to be missed, if the equipment is not tuned up or maintained properly. In some instances the RF transmission lines, rotary joint or beacon antenna can cause problems. Here again, though, this type of problem should be fairly easy to cope with since the equipment is under our control and maintenance.

Signals in Space.

If the assumption is made that both the airborne and ground equipment is performing perfectly and within established standards and tolerances, an analysis of the ATCRBS signals in space can be made. Included in this analysis are the airborne antenna coverage and lobing structure, and airborne antenna shielding when the aircraft is in a bank or turn etc. Vertical lobing in the interrogator antenna pattern, the upper fringe area, or cone of silence, and the lower fringe area site obstructions contribute to missed or fading targets.

CAUSES OF MISSED AND FADING TARGETS

1. Transponder Equipment Malfunction
   - Low Sensitivity
   - Low Power Output
2. Interrogator Equipment Malfunction
   - Low Power Output
   - Low Receiver Sensitivity
   - High Loss in Transmission Lines
   - Variable Loss in Rotary Joint
3. Transponder Antenna Coverage
4. Transponder Antenna Shielding
5. Interrogator Siting Conditions
   - Vertical Lobing
   - Line of Sight Obstructions
6. Cone of Silence

It can, therefore, be seen that although both the airborne and ground equipment is maintained to peak performance levels, and is operated properly, the problem of missed and fading targets will still exist due to the nature of signals in space. How to recognize these problems and what can be done about them is the theme of this workshop.

FIXING MISSING AND FADING REPLIES AT LOS ANGELES, O'HARE AND WHITEHOUSE

By George F. Spingler, NA-120 (13)

My topic this afternoon will cover field problems that have been investigated by NAFEC relative to missing and fading replies, and some of the solutions that have been devised to solve these problems.

There are numerous reasons why missing and fading targets occur in the Air Traffic Control Radar Beacon System. Some of these reasons are:

1. Shielding of the aircraft antenna due to the attitude of the aircraft,

2. obstructions in the vicinity of the interrogator site which blocks the radiations from the transmitter to the aircraft, and

3. vertical lobing due to multipath reflections from the terrain in the vicinity of the interrogator site.

The previous speaker covered the subject of how shielding of the aircraft antenna due to attitude can cause a loss of radar beacon replies; so I will not belabor the point except to remind you that most of the loss of replies due to the shielding of the aircraft antenna occurs while the aircraft is maneuvering, and not during level flight.

<u>LA Field Test.</u>

Regarding the loss of replies due to obstructions in the vicinity of the interrogator site, in January of 1964, field tests were conducted at Los Angeles, California, to test the experimental model of the Improved 3-Pulse Side Lobe Suppression System which was designed and fabricated by NAFEC.

The Improved SLS System was installed at the Los Angeles ASR-4 Site, and flight tests were conducted in the vicinity of the Los Angeles International Airport, using radials of the Los Angeles VOR. Whenever the flight test aircraft was flown behind the IBM building, loss of radar, radar-beacon, and communications was experienced, particularly when the aircraft altitude was 1,000 feet or less.

Since the Los Angeles ASR-4 radar beacon was installed in the proximity of the Los Angeles International Airport, aircraft would fly at altitudes of 1,000 feet, or less, while executing flight maneuvers in preparation for landing and after take-off. The loss of replies due to the IBM building was clearly a case of missing replies caused by a "high-rise" building in the vicinity of the interrogator site. The radiation shadow area caused by the IBM building was obvious in this case, but in some instances, radar beacon sites could have obstructions, such as trees, which are easily overlooked. Obstructions in the vicinity of the interrogator site are more likely to occur at Terminal Sites than at En Route Sites due to the smaller towers used, at most times, at the Terminal Sites.

During the flight tests that were conducted at the Los Angeles ASR-4 Radar Beacon Site, not only was the IBM building found to be an obstruction, but the ASR-4 Radar Microwave Link tower also blocked radiation from the Site. The effect of the RML tower was to decrease the size of the radar beacon replies as the aircraft flew behind the RML tower. Side lobe returns were also noted at the Los Angeles ASR-4 Site due to the obstruction of radiation by the RML tower.

O'Hare Field Test.

A request was made in March of 1970 by the Central Region for NAFEC's participation in the investigation of the O'Hare problem area. The loss of transponder replies in an area approximately 11 nmi south-southwest of the O'Hare ASR-4 radar beacon, from the Warren Intersection to the McCook ARSR-2 Site, had existed since 1967; about the same time that the Improved SLS System was installed on the ATCBI-3 interrogator. The loss of radar beacon coverage affected the control of normal air traffic on the approaches to the southern portion of dual runway 32 left, as well as departure and arrival flights which flew through the area.

Considerable effort had been expended prior to this by Chicago Area Office personnel to determine the cause of the radar beacon coverage loss. The effort was largely impeded by their inability to measure the signal strength of the interrogations received by an aircraft transponder from the ASR-4 radar beacon interrogator. A NAFEC aircraft (N-249) had been instrumented and used on a number of projects which required measuring the signal strength of such interrogations. This aircraft was, therefore, considered suitable for measuring and determining the cause of the radar beacon fade-out of transponder replies in the vicinity of the O'Hare Airport.

The NAFEC aircraft was flown to the Chicago O'Hare Airport on March 17, 1970, and flight tests were conducted in the area.

The loss of Radar Beacon replies in an area, such as that reported by the Chicago Area Office, can be attributed to many causes. Some examples of these are:

1. Improper adjustments of the interrogator site transmitting or receiving systems.

2. Overinterrogation of aircraft transponders in the problem area.

3. Over suppression of aircraft transponders in the problem area.

4. Shielding of the aircraft antenna during maneuvering.

5. Desensitizing of the aircraft transponder by radio frequency radiations in the area.

6. Shadowing of airspace by buildings or other obstructions in the vicinity of the interrogator site.

7. Vertical lobing problems, particularly a mismatch of the omni-directional and directional antenna lobes.

One of the first checks that was performed upon arrival at the Chicago O'Hare Airport was an investigation of the ATCBI-3 interrogator parameters. The "main channel" of the ATCBI-3 was the only channel that was modified with Improved 3-Pulse SLS, therefore, this channel was used for the flight tests and was checked prior to flight testing. A measurement of the transmitter output showed that the P_1 and P_2 pulses were rather narrow so they were readjusted to meet the U. S. National Standard. The power output of the transmitter measured 375 watts and the receiver tangential sensitivity measured -84.2 dBm. Further checks were made and the details of these can be found in Report No. FAA-RD-70-75, published by NAFEC and entitled, "Investigation of Transponder Reply Fade-Out in the Vicinity of Chicago O'Hare Airport," a copy will be handed out at the coffee break.

A measurement of the STC curve showed that a 47.4 dB STC curve was used. The STC curve of 47.4 dB (at 15.36 s) is rather stringent, but this is the curve that was determined to be correct through SAFI flight tests of the facility. The STC curve is based on normal radio frequency attenuation due to propagation (6 dB for each time the range is doubled). Particular attention should be paid to the fact that an excessive STC curve can be instrumental in causing loss of radar beacon replies with <u>abnormal</u> propagation; e.g., if there is vertical lobing, aircraft antenna shielding, substandard airborne or interrogator equipment, etc. Every effort should be made to keep the STC curve as low as possible.

At the present time, the FAA utilizes the STC curve to eliminate directional antenna side lobe replies from non-SLS-equipped airborne transponders as well as radar beacon replies due to reflections. Consequently, radar beacon replies can be lost due to the rigid control of the STC curve whenever propagation from the aircraft transponder to the interrogator is attenuated more than normal.

<u>Aircraft Overinterrogation Detector</u>.

As stated earlier, overinterrogation can cause a loss of radar beacon replies.

Whenever the number of interrogations received by an aircraft transponder exceeds 1,000 per second, the transponder sensitivity is automatically decreased. This reduction in sensitivity can be as great as 30 dB if the interrogation rate equals 1,800 interrogations per second. With reductions in the sensitivity of the transponder of this magnitude, a loss of radar beacon replies can occur in areas of overinterrogation, particularly if the aircraft is at a considerable distance from the interrogator, although the flight test aircraft was very close to the interrogator during these tests.

NAFEC aircraft (N-249) had previously been used to conduct tests in overinterrogation areas and was instrumented to detect the number of interrogations received while flying through such an area. The same instrumentation was used during flight tests in the area south of the Chicago O'Hare ASR-4 Site (Figure 67).

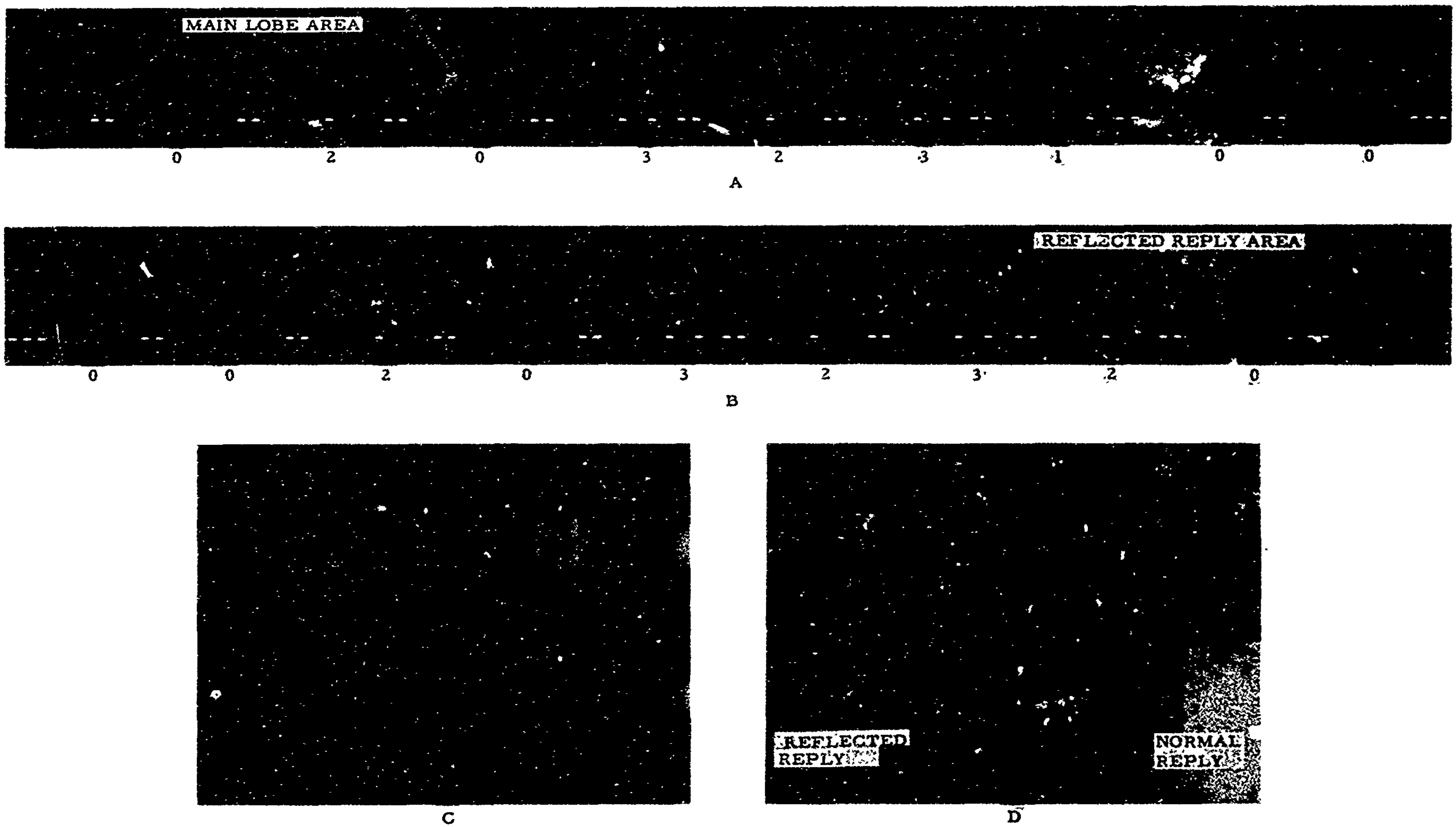


FIGURE 67. DATA SHOWING RADAR BEACON REPLIES DUE TO REFLECTIONS FROM REMOTE TRANSMITTER SITE TOWERS

During the flight tests in the O'Hare problem area, at altitudes between 2,000 and 6,000 feet, the maximum number of interrogations per second that was measured was 551, while the average number of interrogations per second was 340. Since the interrogations rate of the transponder never exceeded 1,000 interrogations per second, the association of the O'Hare radar beacon problem-area with overinterrogation of the test transponder was dismissed.

Airborne Oversuppression Detector.

As stated earlier, oversuppression can cause a loss of radar beacon replies (this is too many side lobe suppressions). The reason why oversuppression of aircraft transponders was investigated as a possible reason for the loss of radar beacon replies in the O'Hare problem area was that both the O'Hare ASR-4 and the McCook ARSR-2 were equipped with Improved 3-Pulse Side Lobe Suppression, and there could have been other interrogators equipped with SLS in the area.

Flight tests were conducted at altitudes of 2,000, 4,000, and 6,000 feet above sea level in the O'Hare problem area. Three flights were conducted at each altitude. During all of these flight tests, the number of side lobe suppressions produced in the test transponder were recorded. The maximum number of side lobe suppressions recorded was 1,012 while the average number of side lobe suppressions recorded was 700. The average number of side lobe suppressions recorded during the flight tests (700) was approximately the combined pulse repetition frequencies of both the O'Hare ASR-4 Site (380) and the McCook ARSR-2 Site (360). This was to be expected due to the proximity of the flight test aircraft to each site, both of which were equipped with Improved 3-Pulse SLS.

From the number of side lobe suppressions recorded during the flight tests, it was concluded that the missing radar beacon replies could not be attributed to excessive side lobe suppressions.

Dual Input Transponder.

During the flight tests in the Chicago O'Hare problem area, tests were performed using a bottom antenna only and using both a bottom and a top antenna together with the Dual Input Transponder. When a Dual Input Transponder System was used, considerable improvement was noted in the replies obtained from the flight test aircraft during turns and other maneuvering, but radar beacon replies were still lost in the O'Hare problem area while the aircraft was flying straight and level.

Subharmonic Frequencies.

The results of early SAFI flight tests in the O'Hare problem area indicated that broadcast frequency antenna towers were associated with some areas where radar beacon replies were lost. Even though the frequency radiated by these towers was not 1,030 MHz, certain subharmonics of 1,030 MHz have shown the ability to desensitize radar beacon transponders during recent tests performed at NAFEC; particularly, if the signal strength of the lower frequency radiation was very intense.

One of the tests that was completed in the Chicago O'Hare area, using the NAFEC aircraft, was performed to determine if the test transponder was being desensitized by a very intense electromagnetic radiation. A signal generator was installed on the aircraft and used to insert a pulsed 1,030 MHz signal of constant amplitude into the transponder while the aircraft flew through the area where beacon replies were lost (Figure 68). This "reference" pulse was recorded at various times during the flight test but particularly when the aircraft was in the vicinity of the WCFL radio tower. If the transponder was desensitized by a non-beacon radiation received by the aircraft antenna, the amplitude of the reference pulse would have decreased.

Flight tests using this reference pulse were performed at 2,000, 4,000 and 6,000 feet above sea level. The aircraft was less than 1,400 feet above the terrain when it was flying at an altitude of 2,000 feet above sea level, and approximately 1,100 feet above the top of the WCFL antenna tower. The intensity of the signal in the vicinity of the WCFL tower was very high (broadcasting 50,000 watts), but the results of the data obtained during this test, did not show any reduction in the amplitude of the reference pulse. Therefore, the desensitization of the transponder, by radiation from the WCFL radio station tower, was ruled out as a possible reason for the loss of radar beacon replies in the O'Hare ASR-4 problem area.

Obstructions.

Certain obstructions were noted on the horizon south of the Chicago O'Hare ASR-4 Site. Prior to the arrival of the NAFEC flight test aircraft, measurements were made by the Chicago Area Office, of the vertical angles above the horizon occupied by each obstruction. None of these obstructions extended above a vertical angle of 1 degree above the ASR-4 radiation horizon.

During the analysis of the Chicago O'Hare flight test data, it was noted that radar beacon replies from the flight test aircraft were also lost when the aircraft was flying in the O'Hare problem area in the vicinity of the 212 degree radial. Further investigation of this azimuth revealed that the towers of the Remote Transmitter Site No. 1, adjacent to the ASR-4 Site, were approximately at the same azimuths as those where the problem occurred.

The four remote transmitter site towers were approximately 40 feet tall with a 3-foot tall platform on the top of each tower. The towers were 4 foot by 4 foot and the platforms on top of the towers were 8 foot by 8 foot.

Side lobe returns were also received from the flight test aircraft while it was flying at an azimuth of the ASR-4 Site associated with the remote transmitter site towers. The side lobe replies indicate that the omni-directional signal was attenuated by the towers more than the directional antenna signal. This was probably due to the relative size of the omni-directional and directional antennas. Since the directional antenna had the larger aperture of the two antennas, the directional antenna was not attenuated as much as the omni-directional antenna, but some loss of radar beacon replies was also caused by the remote transmitter site towers.

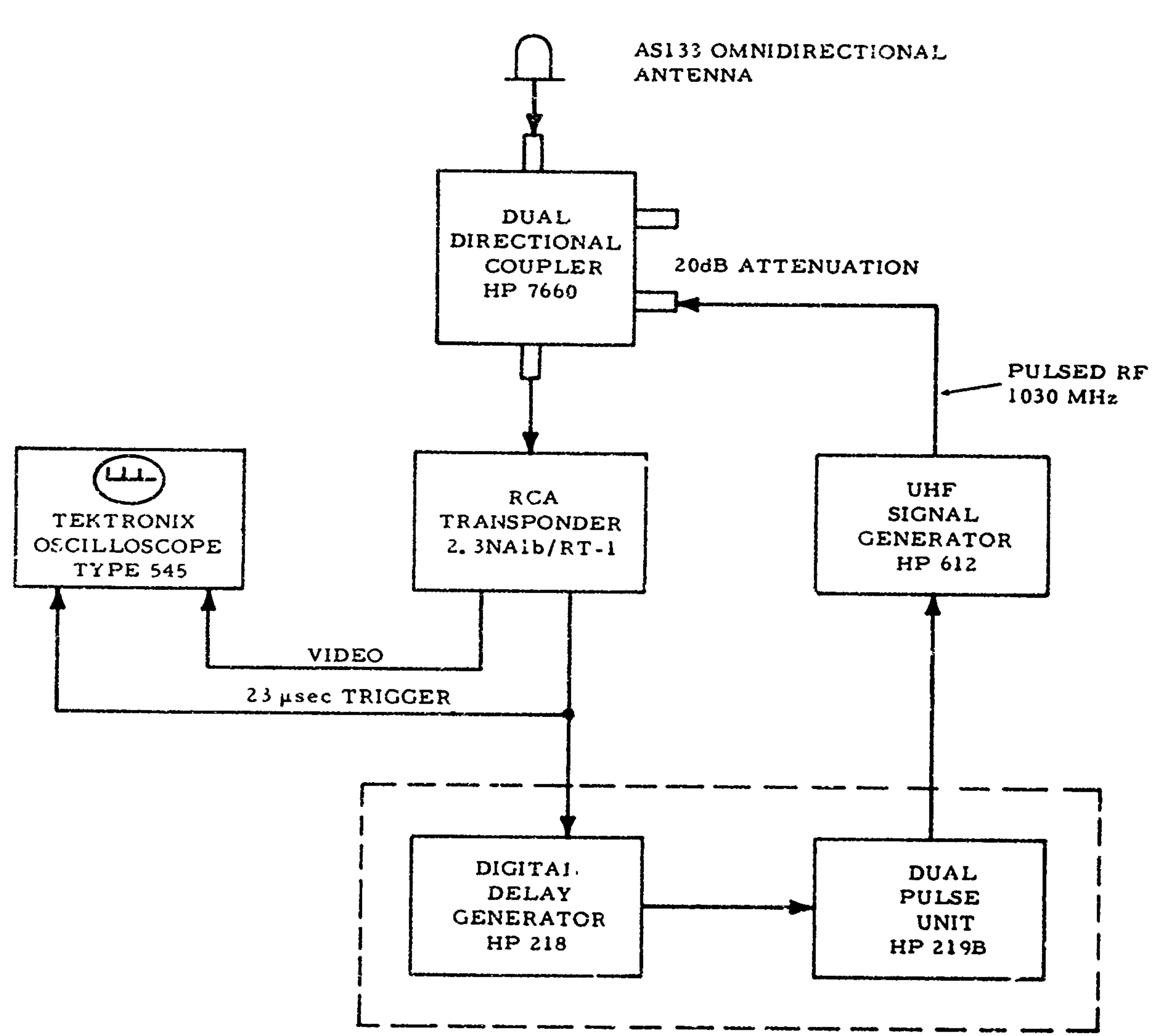


FIGURE 68. BLOCK DIAGRAM OF EQUIPMENT USED TO DETERMINE DESENSITIZATION OF TEST TRANSPONDER

Photographic Data.

During the flight tests that were performed in the O'Hare problem area, photographic records were obtained of each interrogation that was received in the flight test aircraft from the O'Hare ASR-4 Radar Beacon Site. To enable observation of just those interrogations that were produced by the O'Hare ASR-4 Radar Beacon Site, a special synchronization system was established. The details of the synchronization system used to photograph and view the interrogations from just the Chicago O'Hare ASR-4 Site can be found in the report FAA-RD-70-75 on Chicago O'Hare.

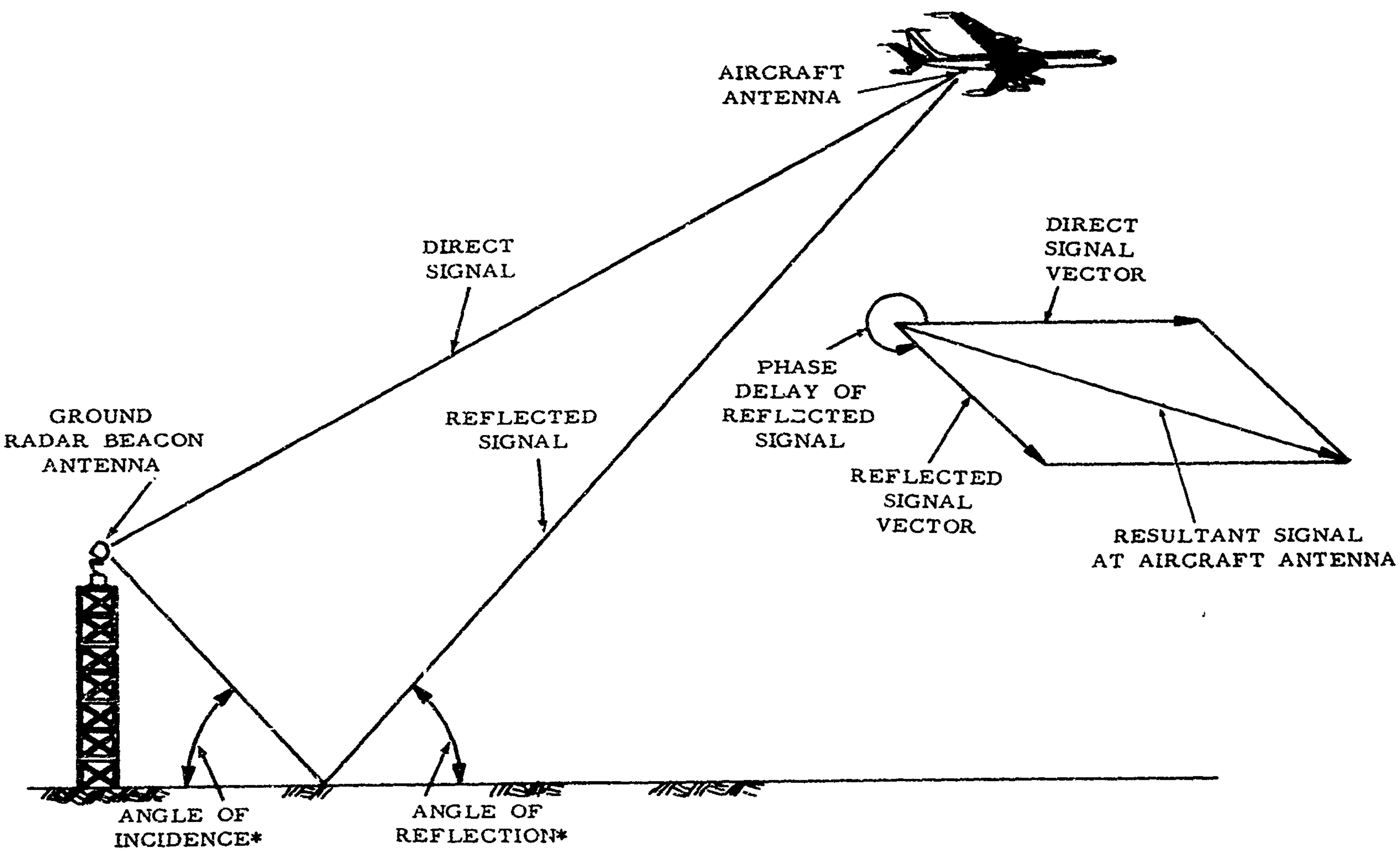
During the flight tests, photographic data were simultaneously obtained in the O'Hare Instrument Flight Rules maintenance equipment room using the maintenance plan position indicator console. One frame of photographic data was taken for each sweep of the ASR-4 antenna. The time that each photograph was taken was inserted in the camera data chamber and appeared on each frame of the film in the final processing. This time was used to correlate the ground and airborne data so that the signals recorded in the aircraft could be related to the radar beacon replies received on the ground from the flight test aircraft.

Analysis of the data obtained at Chicago showed that the presence of the remote transmitter site towers were the cause of a loss of radar beacon replies and side lobe returns in the O'Hare problem area.

Vertical Lobing.

If an air traffic controller knows that aircraft under his control are flying straight and level, and there is a loss of radar beacon replies from this aircraft, there is a good possibility that this could be caused by vertical lobing. If the air traffic controller sees aircraft replies fade at one altitude in a certain area but not at another altitude in this same area this could also be caused by vertical lobing.

The phenomenon of vertical lobing, which can be responsible for the loss of radar beacon replies, is caused by multipath propagation between the interrogator and the aircraft (Figure 69). With vertical lobing, not only is the direct path from the interrogator to the aircraft available for propagation, but a second path, from the interrogator to the aircraft via a reflection from the terrain surrounding the interrogator, is also available. When more than a single propagation path exists between interrogator and aircraft, phasing between the signals, which follow the two paths, can occur. When the two paths provide signals which are "in-phase" with the aircraft antenna, the signals add, and the intensity of the resultant signal could be as much as twice that which would have been received via only a single path (6 dB). When the two paths provide signals which are "out-of-phase," the resultant signal is decreased and could be completely eliminated if the two paths provided equal signals which were exactly 180 degrees out of phase.



* ANGLE OF INCIDENCE ALWAYS EQUALS ANGLE OF REFLECTION

FIGURE 69. THE BASIC PHENOMENA THAT CAUSES VERTICAL LOBING

The intensity of the signals reflected from the terrain surrounding an interrogator is determined by:

1. The height of the surface irregularities of the terrain surrounding the site, and

2. The type of soil and the angle of incidence of the signal which is reflected by the terrain to the aircraft.

The contour of the terrain surrounding the Chicago O'Hare ASR-4 Site was exceptionally smooth, for a distance of approximately 1 mile, particularly in the area south of the interrogator site. The height of the terrain did not vary more than ±5 feet in the entire area. The soil was a sandy loam which has a high reflection coefficient from very low angles of incidence to angles of incidence up to approximately 20 degrees. Therefore, the terrain surrounding the O'Hare ASR-4 Site was condusive to the generation of radar beacon propagation vertical lobing.

The structure of the vertical lobing pattern of any site is directly related to the height of the interrogator antenna above the reflecting terrain which surrounds the site. As the terrain varies in height, it is equivalent to the height of the antenna varying up and down above a constant reflecting plane.

Analysis of the data obtained in the O'Hare problem area showed that the beacon replies displayed on the IFR Room PPI continuously varied from a wide reply to a very narrow reply in the area south of the ASR-4 Site. The radar beacon reply from the flight test aircraft was also completely lost in this same area. From the data collected during the flight test, it is evident that the loss of radar beacon replies and the variation in the width of the replies were due to vertical lobing.

If an aircraft should fly through the problem area with a weak transponder, a repeated loss of radar beacon replies could result. A loss of radar beacon replies would also occur if the attitude of the aircraft attenuated the airborne antenna signal in any way; e. g., during a departure or arrival. The existence of vertical lobing in the propagation pattern of a site that uses an interrogator receiver STC curve of 47.4 dB can also result in a loss of radar beacon replies due to the rigid control exercised by the STC curve and the variations of signal amplitude caused by vertical lobing.

Correcting Vertical Lobing.

Since some loss of radar beacon replies in the O'Hare problem area was traceable to vertical lobing of the propagated signals, correction of the problem lies in eliminating the multipath signals. If just the direct-line signal path, from the interrogator to the aircraft, was available for propagation, there would have been no cyclic variation of the signals received in the aircraft. Therefore, if the signals that were propagated from the interrogator to the aircraft, via a terrain reflection, could have been eliminated or even greatly reduced, the variation of signal levels due to vertical lobing would have no longer be a problem.

The vertical angles of the ASR-4 Site coverage to an aircraft flying through the problem area are between 2 degrees and 7 degrees. If the signals reflected by the terrain to an aircraft flying at these vertical angles could have been eliminated, only the direct-line signals would have been available for propagation.

There are a number of ways of eliminating a terrain-reflected signal. Two examples of these are:

1. Roughing the terrain to scatter the reflected signals in lieu of producing a specular reflection, and

2. Blocking the signals which would normally impinge on the terrain at the appropriate angles.

The Rayleigh Criterion, which is used to determine surface roughness, indicates that it would require the installation of a very large number of long furrows of soil approximately 7 feet tall to produce an effective scattering surface. Even if such conditions could be established, it is doubtful that the furrows could be maintained since erosion by wind, rain, and frost would eventually level the area.

The signals that were reflected to the aircraft from the terrain can be blocked by many devices Figure 70. A fence and a mound of soil can be used to effectively block these signals, as well as trees and shrubs. The purpose of a fence, would be to redirect the signals that would have normally been reflected by the terrain so that they strike the terrain at the Brewster Angle and are absorbed. The angle of the mound of soil (31 degrees) was chosen so that energy impinging on it would be absorbed if the soil were sandy loam. The reflection coefficient of sandy loam is extremely low at angles of incidence of 35 degrees. The range to the mound and the inclination would provide angles of incidence ranging around 35 degrees. Therefore, the energy impinging on this mound should be absorbed rather than reflected.

The natural foliage of trees, can be used to absorb radiant energy at 1030 MHz. The foliage of the trees also scatters the energy that is reflected due to the random alignment of leaf/needle surfaces. Evergreen trees, i. e., cedar, pine, spruce, etc., would offer the best year-around radiation screen since they retain most of their foliage during the winter months.

A fence is probably the fastest and easiest radiation barrier to construct and should be tried prior to attempting a more complex modification. The fence should be constructed of a fine mesh (possibly one-half inch) and mounted using poles. The fence should be 20 feet tall, inclined toward the site at 16.5 degrees and formed in a portion of a circle to include the site azimuth angles which are troublesome.

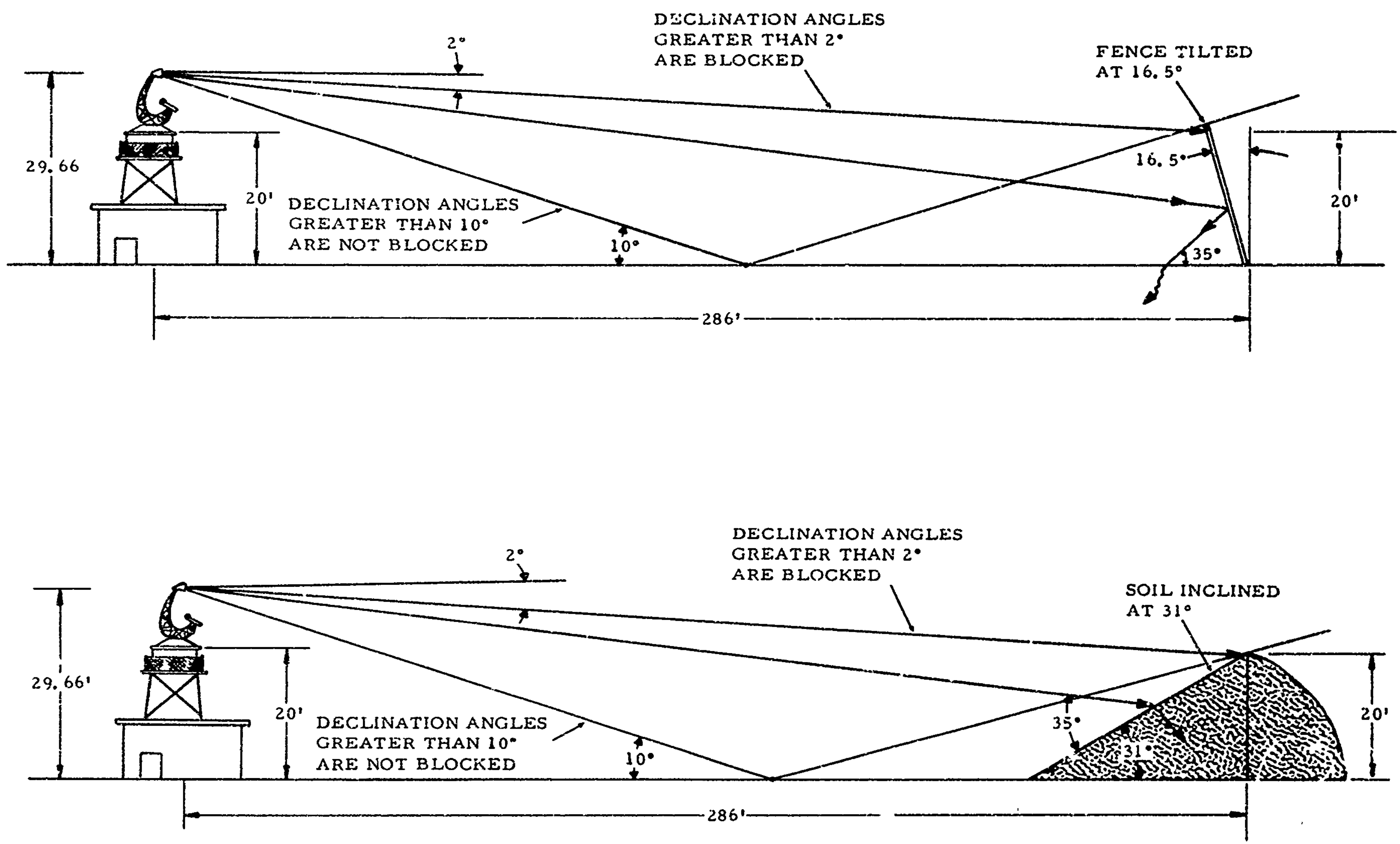


FIGURE 70. MODIFICATION OF ASR-4 SITE TO ELIMINATE VERTICAL LOBING

The mound of soil would accomplish approximately the same purpose as the fence, but it would be possibly more esthetic in appearance. The soil could be obtained from the area behind where the mound of soil will be formed or trucked to the area. A covering of grass would be required on the mound of soil to prevent erosion.

The trees and shrubs would be the most difficult screen to produce, but would probably be the most effective (Figure 71). The depth of the trees could be altered to increase the vertical angle at which radiations are blocked if problems occurred at high angles of elevation. The depth of the trees required for this type of screen would naturally depend upon the type of trees used. The more dense the foliage, the less the depth of foliage that would be required. The trees could be planted in rows at various distances from the antenna provided that each row of trees was dense enough to provide adequate screening. One disadvantage of this type of screen is that it must be maintained from year-to-year to insure that the foliage does not grow too high.

Remote Transmitter Towers.

Part of the fix recommended by NAFEC for implementation at Chicago O'Hare was to move either the Remote Transmitter Site, Number 1 towers or the ASR-4 Site. The Central Region decided to await the installation of the ASR-7 scheduled to take place in 1971 rather than implement fixes on the present ASR-4/6 radar beacon.

By the way, the Remote Transmitter Site towers that existed at Chicago were very similar to the towers that presently exist on the Washington National Airport very close to the ASR-7 radar beacon antenna towers. I have already been contacted about problems that exist at the Washington National Airport ASR-7 site and I have indicated that the towers could present an obstruction to radiation.

The Whitehouse Problem.

The field tests that were conducted at Chicago O'Hare took place almost two years ago. More recently, a request was received in September of 1971 from the Southern Region for NAFEC assistance to determine the reasons for the loss of radar beacon replies in the Whitehouse, Florida ARSR-2 coverage area. Radar beacon replies, to interrogations from Whitehouse, were being lost at site radials between 340 and 120 degrees. The site radials around 90 degrees were particularly critical (Figure 72), since the Whitehouse radar beacon system was the only system that was capable of covering this area which included the Gateway Intersection. The Gateway Intersection is on the main north-south airway between New York and Miami, Fla., and is approximately 150 nmi off the coast of Florida and 175 nmi from the Whitehouse site.

An inspection of the Whitehouse Site (Figure 73) showed that the terrain in the vicinity of the site was extremely flat and the site radials between 340 and 120 degrees had practically no tree cover. The remainder of the site radials did have tree cover and these radials were virtually free of vertical lobing problems.

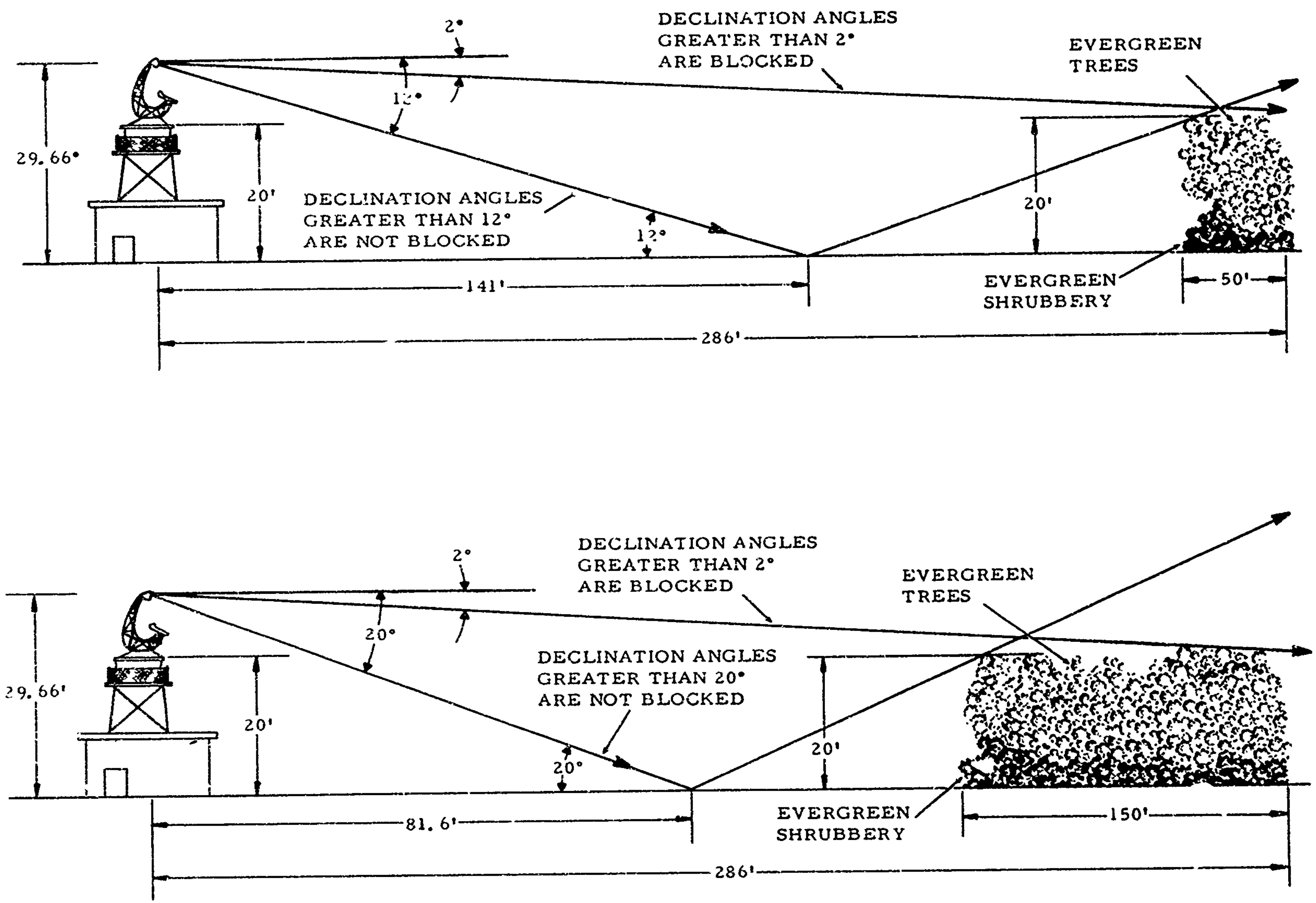


FIGURE 71. MODIFICATION OF ASR-4 SITE TO ELIMINATE VERTICAL LOBING USING TREES

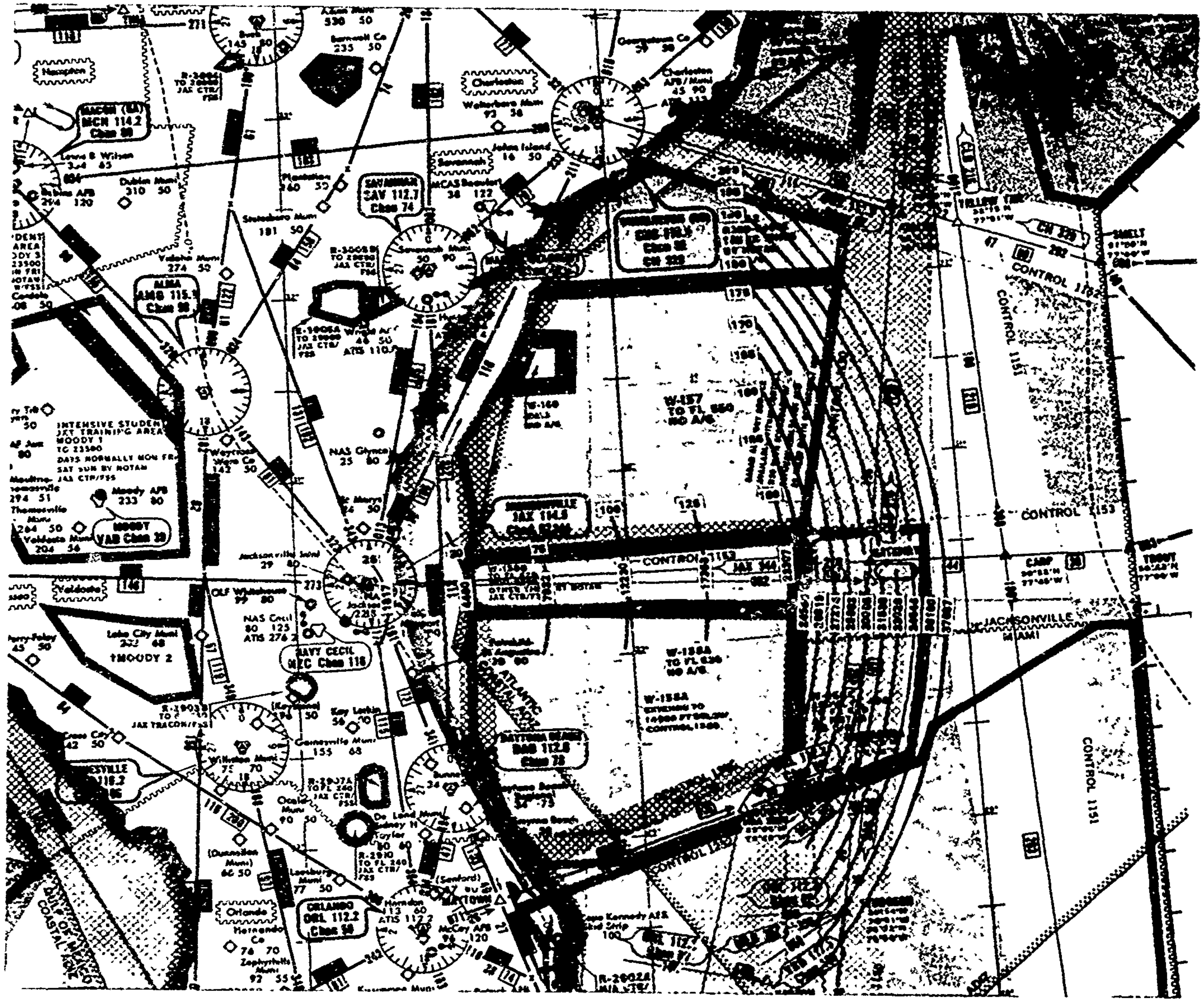


FIGURE 72. WHITEHOUSE, FLORIDA, ARSR-2 BEACON COVERAGE AREA

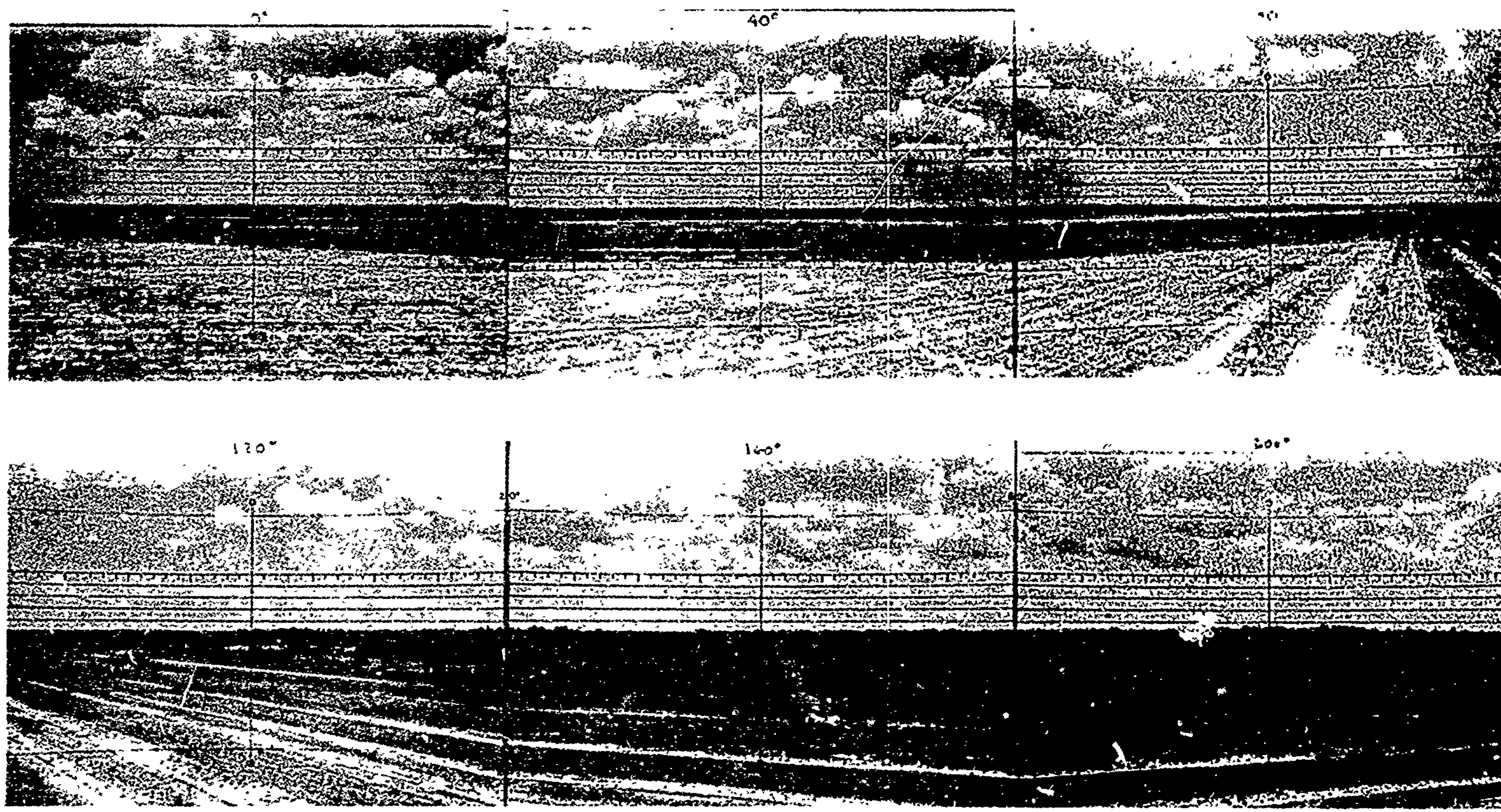


FIGURE 73. WHITEHOUSE, FLORIDA, RADAR BEACON SITE

Flight tests were conducted within the coverage area of the Whitehouse, Radar Beacon System on 17 and 18 September 1971, by NAFEC personnel. A Grumman Gulfstream, N-376, equipped with a transponder calibrated to meet the requirements of the U. S. National Standard, was used to determine the extent of the coverage problems in the Gateway Intersection area and on site radials between 340 and 120 degrees. Coverage in the areas between site radials 340 and 80 degrees was minimal, but coverage in the area of the Gateway Intersection was very inadequate. With the Grumman Gulfstream flying at an altitude of 26,000 feet and a range of approximately 165 nmi, the radar beacon reply from the flight test aircraft was completely lost at azimuth bearings between 82 and 88.5 degrees. Additional coverage losses were also recorded at azimuth bearings between 100 and 106 degrees when the flight test aircraft was flying at ranges approximating 170 nmi from the site.

Fixing With Fences.

At the completion of the flight tests at Whitehouse, Florida, additional testing was conducted at NAFEC, outside of Atlantic City, New Jersey, to prove that the erection of fences in the vicinity of reflecting terrain could effectively reduce the vertical lobing problem at Whitehouse. The tests were performed to determine (1) the type of fencing material that should be used in the construction of such a fence, and (2) the most advantageous location for such a fence when used to attenuate the signal reflected from the terrain.

A horn antenna was used as a receiving antenna and was positioned 2,5000 feet from the transmitting antenna. The transmitting antenna was on top of the NAFEC Building 14 tower and can be seen, at a distance, above the horn antenna. The horn antenna remained stationary during the tests while the screen containing the various screening materials was moved 1, 2, 5, and 10 feet from the horn antenna (Figure 74).

The three types of material used for the fencing (Figure 75) shown left to right, were:

1" Poultry Fence
Window Screening
1/2" x 1/2" Hardware Cloth

The results of the screen mesh attenuation tests showed that the 1/2" x 1/2" Hardware Cloth is as effective as the Window Screening, but when the effects of attenuation, wind resistance, and cost were considered, the 1/2" x 1/2" Hardware Cloth was found to be the most effective screening.

The second series of tests, performed at NAFEC, were conducted to determine the effectiveness of using various size screens covered with the 1/2" x 1/2" Hardware Cloth to attenuate the terrain reflection. A 2,000 foot experimental test range was established using antenna separations and heights designed to produce a decided decrease in signal or null due to a reflection from the terrain. The point of reflection from the terrain was selected so that the area producing this reflection was very flat. One antenna was placed

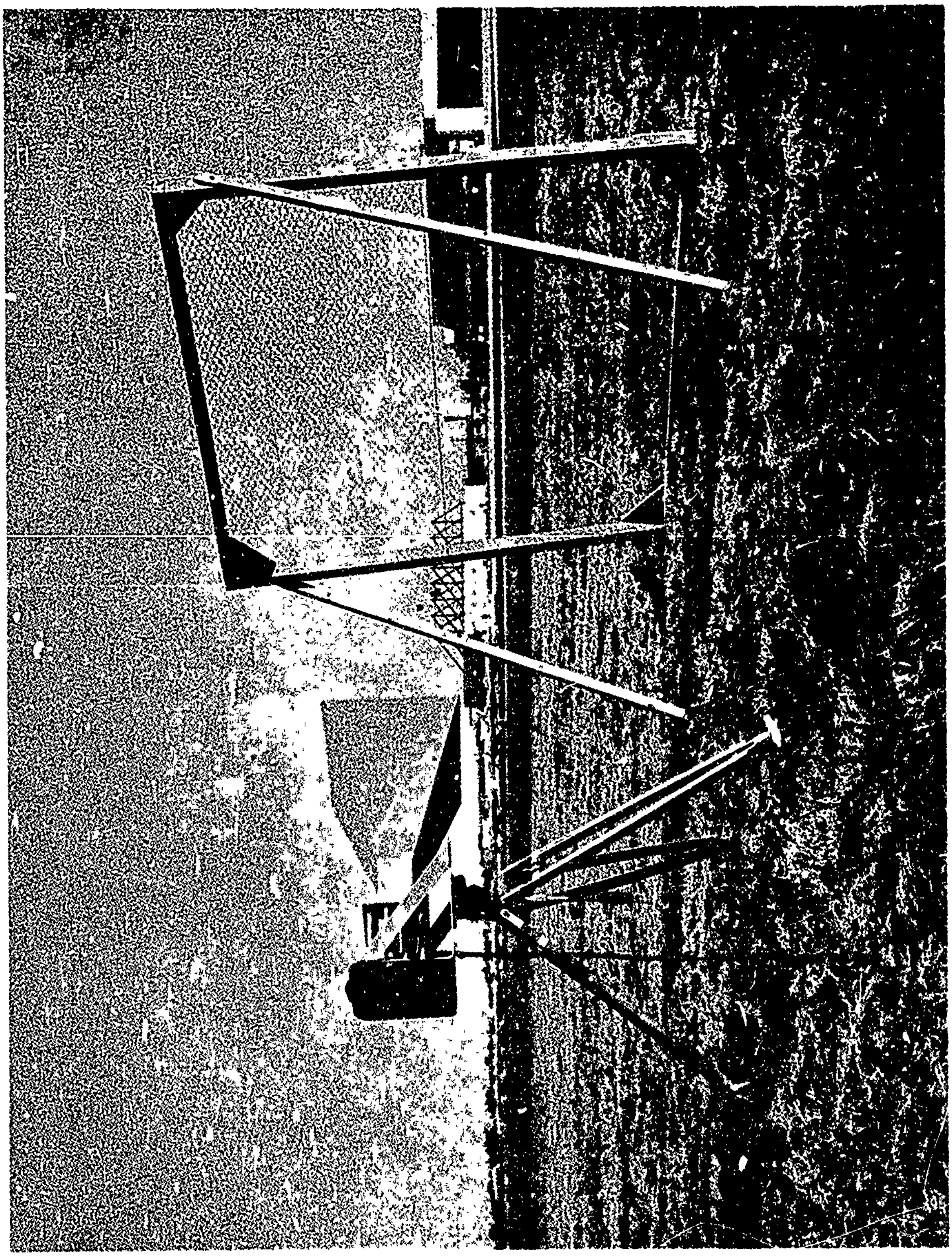


FIGURE 74. HORN ANTENNA AND SCREENING

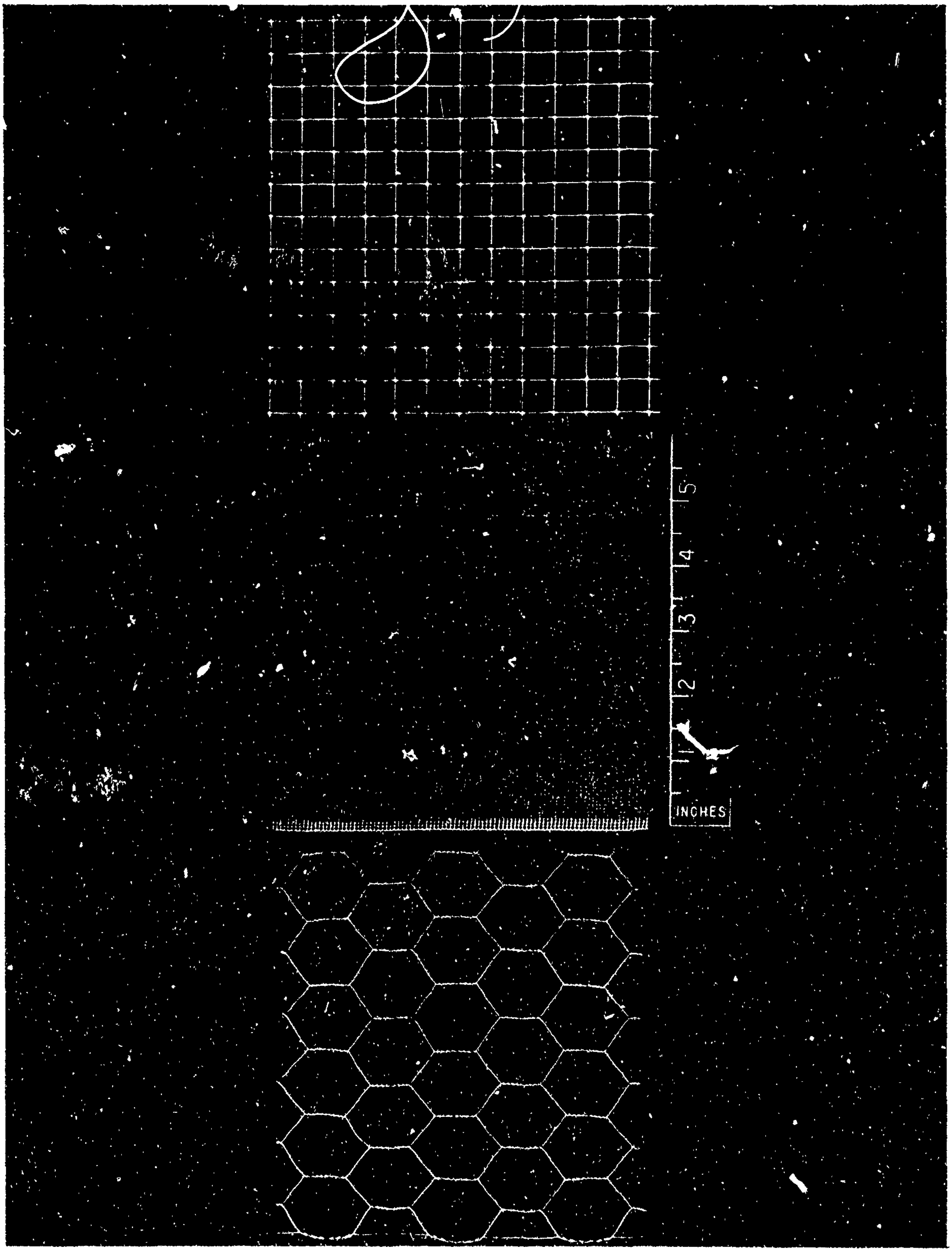


FIGURE 75. THREE TYPES OF SCREEN MESH

at a height of 30.9 feet, and was used for transmitting a 1030 MHz signal to the other antenna used for receiving the signal. When the two antennas were elevated to the same height, the point of reflection was halfway between the two antennas. This point of reflection midway between the two antennas was used during the tests as the area in which the shielding fences were introduced (Figure 76).

During the tests, the depth of the null was measured prior to the introduction of the shielding fence and also after the fence was placed in position. Relative readings were taken between the signals received in the null and the signal intensities which were measured at the height of the maximum, which occurred in the vertical lobing pattern, adjacent to this null. All fences were tilted toward the transmitting antenna at an angle of 17 degrees from upright, so that any signals that might be reflected from the shielding fences back toward the transmitting antenna would strike the terrain at the Brewster Angle and would, therefore, be absorbed in the terrain rather than reflected from the terrain.

Two fence configurations were used during the experimental tests. The one series of tests utilized a 6-foot high shielding fence, while the other tests were made with a 12-foot high fence. The data that resulted from the test were a comparison between the signal intensities measured with the receiving antenna positioned in the first null and in the second maximum of the vertical lobing pattern.

1. TESTS PERFORMED WITH 6-FOOT FENCES

		Minimum (Null)	Maximum (2nd)
a.	Calibration of Test Site (No Fences)	11 dB	35 dB
b.	Placed 6' x 48' Fence at Mid-point between antennas.	20 dB	33 dB
c.	Two Fences 6' x 48' - one Fence at Mid-point, the Other 200' From Mid-point Toward Transmitting Antenna.	24 dB	31.5 dB
d.	Two Fences 6' x 48' - Each Placed 200' Either Side of Mid-point.	26.5 dB	31 dB
e.	Single Fence 6' x 48' - Placed 200' From Mid-point Toward the Transmitting Antenna.	18.5 dB	31 dB

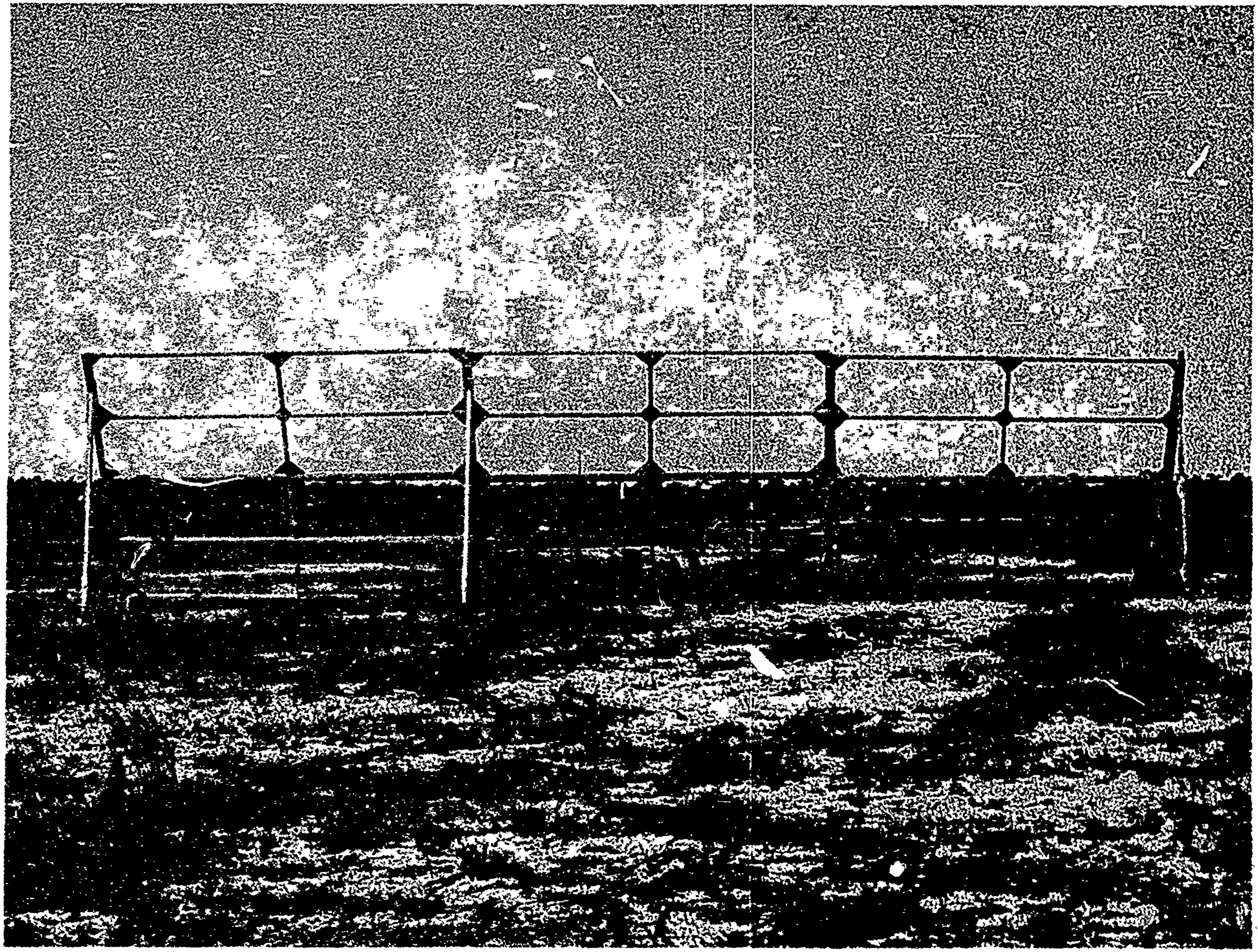


FIGURE 76. SHIELDING FENCE AT POINT OF REFLECTION MIDWAY BETWEEN SENDING AND RECEIVING ANTENNAS

2. TEST PERFORMED WITH 12-FOOT FENCE

a.	Calibration of Test Site (No Fence).	9.5 dB	35 dB
b.	Placed 12' x 48' Fence at Mid-point Between Antennas.*	28 dB	28.5 dB

*Output power of the transmitter had decreased 1/2 dB since calibration tests.

The results of the experimental tests conducted at NAFEC show that a 12-foot fence, placed at the mid-point between the transmitting and receiving antennas, provided a larger attenuation of the terrain reflected signals than either the single or double 6-foot fence configurations. The variation in signal intensities received with antenna positioned in the second maximum of the vertical lobing pattern and the first minimum of the vertical lobing pattern was 1/2 dB, and indicated that the signals reflected from the terrain had been virtually eliminated by the test configuration (Figure 77).

At the completion of the tests at NAFEC, a conference was held between the Southern Region, Washington (SM & RD) and NAFEC. At this conference, it was decided that a fence should be errected on the Whitehouse Airport to eliminate the terrain reflection that was responsible for the loss of replies in the Gateway Intersection.

A thorough inspection of the terrain in the vicinity of the Whitehouse site on the 90 degree radial was undertaken along with a mathematical analysis to determine the terrain areas responsible for the problem.

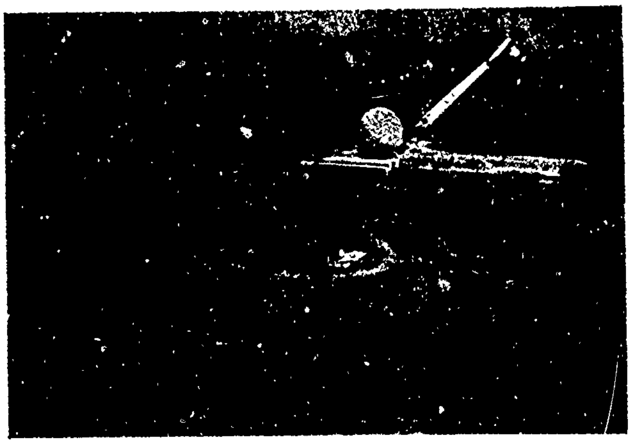
The area of the terrain reflection was found to be the end of Runway 11 on the Whitehouse Airport.

A plan was devised to install a series of fences along the side of the runway to attenuate the ground reflection and this plan was sent to the U. S. Navy, who was responsible for the Airport property. After deliberation, this proposal was turned down by the Navy because of the safety hazard that it presented.

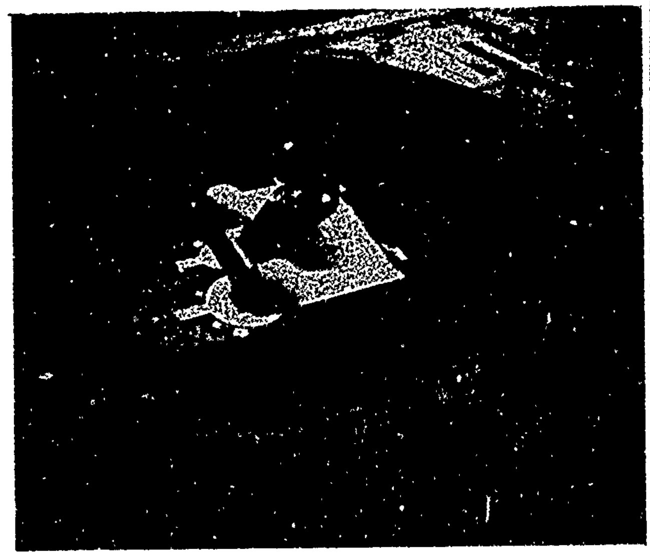
At the present time, an alternative plan is being sought. Some of the suggestions that are being considered are:

1. Moving the fence closer to the Whitehouse radar site, away from the runway area, and increasing the height of the fence.

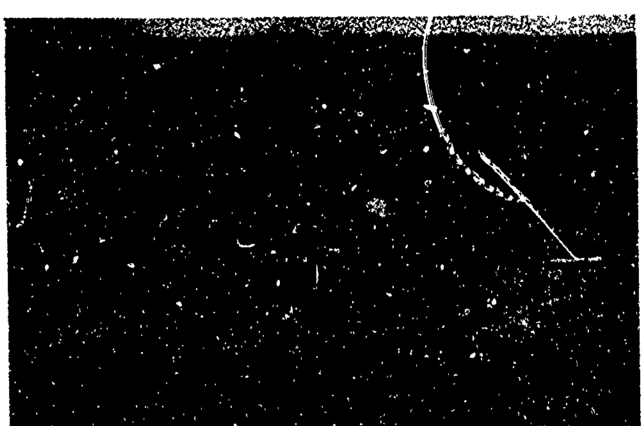
2. Increasing or decreasing the height of the radar beacon antenna to change the vertical lobing structure of the radiated pattern.



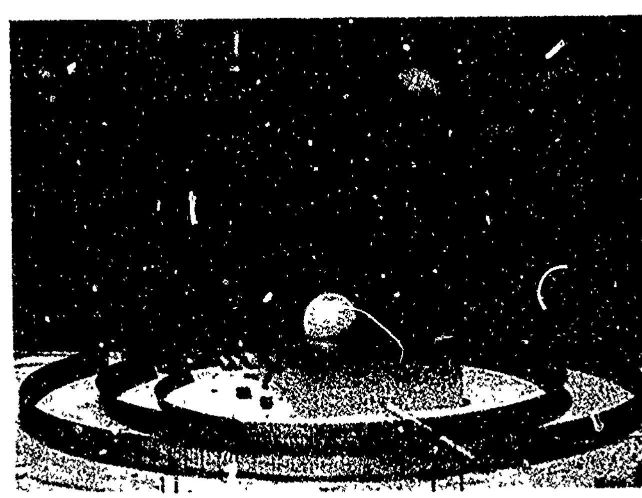
Clutter-suppression fence and ground-reflection-blocking fence for Nike-Zeus Acquisition Transmitting Antenna at White Sands.



Clutter-suppression fence and ground-reflection-blocking fence for MAR installation at White Sands.



Clutter-suppression fence for AMRAD antenna at White Sands.



Fences for blocking ground reflections for the Nike-Zeus Discrimination Radar at Kwajalein.

FIGURE 77. DIFFERENT TYPES OF FENCES FOR REFLECTION BLOCKING

3. Using the radar antenna to radiate the radar beacon signal and take advantage of the larger vertical aperature of the radar antenna to reduce the amplitude of signals which would strike the terrain at the point of reflection. The radar antenna is also at a lower height that the radar beacon antenna which would change the vertical lobing structure of the radiated pattern.

COMPUTER METHODS FOR FINDING MISSING TARGETS

By Frederick A. Liebe, ATS-826 (24)

I have brought with me from the New York Common IFR room some of the computer data that we've used for troubleshooting for explaining the problems that we've heard about at the seminar today (Figure 78).

Putting it on Tape.

The program that we use to do this was developed back in 1969, when George Spingler and group were up at the common IFR room, programers extracted the program. What we're doing is we're putting on tape all the beacon equipped aircraft - anyone responding on code 3A or C - and then bringing it out.

We then pick a period of time where we have experienced a problem, and pick out a discreet 4096 code. What we get is a full computer printout page. You have time in the first column; range, and azimuth are subsystems. The identity beacon code, an IBM number, an altitude, and an A-N number for the altitude.

We can see looking down in "time" that each time entry is one scan of the antenna. Going down the list you'll find where an "F" is, that you've got a problem.

If you look at the range and azimuth you can see that the track or the azimuth changed from 359.4 to 326 - we have a ghost.

You keep on going down the list you'll find another ghost - the same reflecting surface.

We precede and now you find you have a miss. We're doing this manually, there is a procedure at NAFEC where they can do this automatically.

We just look at a track of an aircraft going into LaGuardia Airport, on code 1531, and you can see the number of misses that we can account for on a normal track of an aircraft which the controller is seeing everyday. What's significant to note is that a miss is based on not getting more than one hit. If we had 2 hits on that target we would have probably printed them with a low A-N number. When we don't print them, we know we didn't get more than one hit, which means that the controller saw nothing on his display.

When we look at what a controller sees on a display; we see whole flock of false targets with a series of misses. With the data off these charts you can very easily calculate a search area for your false targets. You also have some reasons to go investigate hardware for missing targets.

DATE 12/~~11~~/69 9

JFK
C/m I
SLS Power increased
3db

Scan
Miss
-11
-15
-19
-23
-29

	TIME	SUBSYSTEM	RANGE	AZIMUTH	BEACON CC
	19 36 03	JFK	003.7	131.3	07
	19 36 07	JFK	003.6	132.0	07
	19 36 11	JFK	003.4	132.4	07
	19 36 15	JFK	003.3	133.1	07
	19 36 19	JFK	003.2	134.0	07
	19 36 23	JFK	003.1	135.0	07
F	19 36 24	JFK	014.8	246.3	07
	19 36 24	JFK	008.9	246.3	07
	19 36 27	JFK	003.0	135.1	07
F	19 36 28	JFK	008.8	247.5	07
	19 36 31	JFK	002.9	136.1	07
F	19 36 32	JFK	014.6	247.1	07
	19 36 35	JFK	002.8	137.0	07
F	19 36 36	JFK	014.5	247.1	07
	19 36 36	JFK	008.6	247.1	07
	19 36 39	JFK	002.6	137.9	07
	19 36 43	JFK	002.5	140.1	07
	19 36 47	JFK	002.4	140.7	07
F	19 36 49	JFK	003.1	314.8	07
	19 36 51	JFK	002.3	143.3	07
F	19 36 55	JFK	002.2	136.9	07
	19 36 55	JFK	002.2	144.8	07
F	19 36 59	JFK	002.1	137.9	07
	19 36 59	JFK	002.1	146.1	07
F	19 37 03	JFK	002.0	110.4	07
	19 37 03	JFK	001.9	137.9	07
	19 37 03	JFK	001.9	146.9	07
	19 37 05	JFK	010.0	350.6	07
	19 37 07	JFK	001.8	148.4	07
	19 37 09	JFK	006.3	353.4	07
	19 37 13	JFK	009.8	350.6	07
	19 37 13	JFK	005.6	351.4	07
F	19 37 17	JFK	009.7	351.4	07
	19 37 17	JFK	005.7	351.3	07
	19 37 21	JFK	009.6	350.8	07
	19 37 25	JFK	009.5	350.8	07
	19 37 25	JFK	005.4	351.8	07
	19 37 31	JFK	001.2	159.3	07
F	19 37 32	JFK	014.4	297.5	07
	19 37 32	JFK	007.8	297.5	07
	19 37 43	JFK	000.9	170.1	07
	19 37 47	JFK	000.8	174.9	07
F	19 37 59	JFK	007.8	230.3	07
	19 37 59	JFK	004.1	230.1	07

FIGURE 78. COMPUTER TARGET PRINTOUT FROM THE NEW YORK COMMON IFR SITE

	04 21 14		JFK	026.2	283.6
	04 21 18		~~JFK~~	~~025.9~~	~~283.3~~
MISS-22 →	04 21 25	— MISS	JFK	025.3	282.9
	04 21 29		JFK	025.1	282.8
	04 21 33		JFK	024.8	282.4
	04 21 37		JFK	024.4	282.2
	04 21 41		JFK	024.2	281.5
	04 21 45		~~JFK~~	~~023.3~~	~~282.0~~
	04 21 49		JFK	023.6	282.1
	04 21 53		JFK	023.3	280.8
	04 21 57		JFK	023.1	280.3
	04 22 01		JFK	022.8	279.8
	04 22 05		JFK	022.5	279.6
	04 22 09		~~JFK~~	~~022.2~~	~~279.4~~
	04 22 12		JFK	021.9	278.9
	04 22 16		JFK	021.6	278.5
MISS-24 →	04 22 20	— MISS	JFK	021.4	278.1
	04 22 28		JFK	020.8	277.2
	04 22 32		JFK	020.6	277.0
	04 22 36		~~JFK~~	~~020.3~~	~~277.2~~
	04 22 40		JFK	020.0	277.4
	04 22 44		JFK	019.8	276.6
	04 22 48		JFK	019.4	276.9
	04 22 52		JFK	019.1	275.6
MISS-00 →	04 22 56	— MISS	JFK	018.8	275.1
	04 23 03		~~JFK~~	~~018.2~~	~~275.1~~
	04 23 07		JFK	017.9	275.1
	04 23 11		JFK	017.6	275.3
	04 23 15		JFK	017.3	275.4
	04 23 19		JFK	016.9	275.7
	04 23 23		JFK	016.6	276.8
	04 23 27		~~JFK~~	~~016.3~~	~~275.4~~
	04 23 31		JFK	016.0	276.6
	04 23 35		JFK	015.8	277.0
	04 23 39		JFK	015.4	277.4
	04 23 43		JFK	015.2	277.7
	04 23 47		JFK	014.9	278.3
	04 23 51		~~JFK~~	~~014.8~~	~~278.9~~
	04 23 54		JFK	014.6	280.5
	04 23 58		JFK	014.4	281.3
	04 24 02		JFK	014.3	282.2
	04 24 06		JFK	014.1	283.3
	04 24 10		JFK	013.9	284.3
	04 24 14		~~JFK~~	~~013.8~~	~~285.6~~
	04 24 18		JFK	013.8	286.5
	04 24 22		JFK	013.6	288.3
	04 24 26		JFK	013.5	288.8
	04 24 30		JFK	013.4	290.3
	04 24 34		JFK	013.3	291.3
	04 24 38		~~JFK~~	~~013.1~~	~~292.5~~
	04 24 42		JFK	013.1	293.6
	04 24 46		JFK	013.0	294.9
	04 24 50		JFK	012.9	296.5
MISS 58 →	04 24 54	— MISS	JFK	012.8	297.1
	04 25 01		JFK	012.7	300.2
	04 25 05		~~JFK~~	~~012.6~~	~~301.4~~
	04 25 09		JFK	012.6	303.1
	04 25 13		JFK	012.6	304.3

We run these on a daily basis. We run 100 scans each day. We tabulate them. There is a computer derived summary at the bottom of the run. It tells us how many hits, how many misses, how many at what A-N number. It gives us an average to expect.

We average our range and azimuth. We have a fixed target that we use for a test target as our evaluating device. We also compare a typical route against a typical route a few months ago.

Comparing Radar and Beacon.

There are many things we also can do, since our system uses beacon digitizer and a radar digitizer, and our system tracks either on radar or beacon. It primarily tracks on beacon but will revert to radar if we lose our beacon, and we're concerned about these missed.

We hope that our radar digitizer will now take over and continue to track. So we're concerned that for each beacon target when it is there we have a corresponding radar target.

We have printouts at night, when the traffic is nominal; only one or two aircraft in the area. We run a printout and we compare to see that a beacon declared target is also a radar declared target. If its not we've got trouble in the system.

Alphanumerics.

The reason we spend a lot of time on this is that the controller who has been plagued by the broken targets, serrated targets, missing and ghost targets in the common IFR room has been living with the problem because of the alphanumeric track. He has been relying on the track to take him through that period of time that he's lost the target. The track will reorientate him as long as the target doesn't stay off the display for more than a few scans. Generally, if its one or two scans we don't hear from the controller at all, but if he suddenly develops a large block, we usually know it before he does, we have a printout from the computer that will signal us that there are missing targets long before the controller has complained. We can institute a search for the malfunctioning component if its a ground system component. We are doing this with the automated system we have. I don't know if ARTS III will give you that capability but its a fallout of the system.

Offline Printouts.

One good thing to mention is that most of these printouts we do cannot be done on line. They have to be done offline. I have to take one of our two computers and take it offline to get a printout. So when the traffic is heavy, I am not able to obtain all this data. I have to do it during nonpeak hours, or at least not later than 10:00 am in the morning, because after this we have traffic buildup. We must go to our dual computer mode.

I brought some slides for the projector.

1. You can see the FAA ILS glide slope building on the left side. That is the source of one of our reflections.

2. Here we have a huge tank that sits right across from the radar, and it has been a source of problems, plus the groundword lobbing.

3. Here is another tank quite a distance out, the SLS is not effective and it gives us a ghost.

This is just typical of 3 clear problems that we have at the Kennedy Airport. They are there all the time.

NOTE: It was not possible to reproduce here the panoramic view displayed by Mr. Liebe.

DETECTING MISSING TARGETS USING AUTOMATION

by Vincent Preston, AFS-22A (20)

Beacon Code Validation

Today I would like to talk to you about a beacon code train processing technique referred to as "Beacon Code Validation". This function, performed by a Common Digitizer in the NAS Stage A system, is basically a code reliability test. Typically, after four or five beacon hits are received from an aircraft, the Common Digitizer begins analyzing the code train information. When two successive identical code trains are received, the CD testifies to the reliability of the code train by turning on a particular bit in the digital message generated for this target. This bit, referred to as the validate bit, signals the data processors in the ARTCC that the code train information contained in appropriate fields of this message have met minimum reliability criterias.

Operating experience in the Jacksonville Center area has indicated that normally over 95 percent of all beacon messages received from the Common Digitizers have been successfully validated. Experience also indicates that the 5 percent non-validated beacon messages cause only minor system degradation.

NAS Stage A Model 1B

At this time it would be very meaningful to trace the use of the validate bit in the NAS Model 1B Operational Program. Thus, let us look at a radar display utilizing the output of the NAS Stage A, Model 1B radar processors. Typically, we would expect to see a symbol representing the actual beacon target and a four line data block attached to or tracking the target. For purposes of this discussion, I will refer to the radar processor as a tracking program and a display program.

Tracking

The tracking program utilizes the 4096 mode 3 code capability for positive aircraft identification purposes. When a discrete validated code train is received it becomes a candidate for automatic acquisition and maintenance of a track, using discrete correlation logic. Non-discrete (64-code) beacon targets become candidates for manual acquisition and standard correlation of a track. In addition validated mode C data is used for slant range correction to correctly locate the beacon datum. In summary, it can be said that the fact that the data block is attached to the proper beacon datum is a result of the tracking program's analysis.

Display

The generation of the beacon target symbol and the contents of the data block are basically the functions of the display program. Validated mode 3 codes will be displayed as discrete symbols, either a double slash = or a box . , depending on controller inserted filtering instructions. The

location of this symbol will be affected by the mode C slant range correction information.

The mode C altitude and reported beacon code fields will be a result of the validated data received from the CD.

A presently inhibited function allows mode C altitude filtering to be used to display mode C targets whose reported altitude is between pre-set upper and lower altitudes.

Low Validation and Its Effect

Tracking - The highest form of track/datum correlation is discrete correlation, and depends upon validated beacon data as a required input. Non-validation causes the correlation process to be lowered to standard correlation which has a lower track confidence level. Non-validated mode C data cannot be used for slant range correction which further reduces track confidence at close ranges.

Display - Obviously non-validated beacon data cannot be used for data block generation. As a result, the mode C and mode 3 fields would not contain received data without proper validation. Also, the DFG symbol presented would be degraded to a single slash symbol, indicating a non-validated beacon return. Lastly, the actual symbol presented on the display would not be positioned as accurately since a mode C correction would not be applied.

Causes of Low Validation

Practical experience with three Common Digitizers interfaced with UPX-14's has indicated that receiver sensitivity and adjustment are the most consistant causes of low validation percentage. Many instances have occurred where no complaints were registered against the broadband beacon system while narrowband users were experiencing data block problems. This points up the need for revised maintenance procedures as well as some form of system monitoring equipment.

Cases of individual aircraft having validation problems have also been experienced and these cases have usually been traced to marginal transponders.

In summary, I would like to emphasize the fact that the use of beacon datum in a narrowband radar tracking system has placed additional requirements on the performance of the Air Traffic Control Radar Beacon System. System degradation that was not as noticeable in the broadband beacon system has many undesirable effects on a radar tracking programs in Model 1B and presumably Model 3D.

OBTAINING A PHOTOGRAPHIC RECORD OF RADAR MONITOR DISPLAYS

By Joseph J. Scavullo, NA-120 (25)

Many projects involving tests of radar and beacon at NAFEC rely heavily on data collection at the operator's display, the radar plan position indicator (PPI). With a data camera, photographs of the PPI can be made at various frame rates. Many useful photographic records at NAFEC have been made by exposing a single 35mm or 16mm frame for every complete scan of the radar. Color film has been especially helpful to the film readers in the discrimination between maps, compass rose, range rings, numerics, and target video.

We have a film with samples of this type of photography taken at various times and places. A first sequence shows airport traffic under control at Chicago's O'Hare Airport operating both on single and dual runways. The second sequence shows coverage by an ARSR-2 at Lynch, Kentucky, on which several sectors depend, both at the Atlanta and the Indianapolis ARTCC's. This Lynch radar sequence had no map because at the time of the filming, the map was classified for security purposes. In the third and later sequence, video from the Lynch Radar is displayed on the Maintenance PPI at the Indianapolis Center along with a map. In the final sequence, black and white film was used on the PPI for the ARSR-2 at Elwood, New Jersey, and this shows part of the traffic flow in the New York metroplex.

In all three sequences you may see examples of the troublesome phenomena we have been talking about. Later, I will try to stop the film and slow down the action for you at points of interest. However, when the camera is running at motion picture speeds of 18 frames per second, exposures taken at one frame per scan will be screened at such a high rate that several hours of recording can be reviewed in a few minutes. Meanwhile, the analyzing projector allows us to control the rate of playback in many ways. For a qualitative analysis, it often is sufficient to operate the camera at cine speeds. Sometimes it needs to be reversed slowly back and forth. Single frames also may be studied in detail.

Now to illustrate with the film:

The airport surveillance radar, located at Chicago, tells a marvelous story. As the first sequence occurs, notice how the video dissolves as aircraft land and take off, or as they discontinue replies by their transponder. Although we cannot tell their altitudes, controllers who know this area can interpret. Some fading targets should fade, but others probably should not be allowed to.

In the next sequence you see excerpts from ARSR-2 data taken in order to discover how many targets were likely to appear concurrently, at different ranges, but within a 4° beam width of the Lynch Radar. By examination of every tenth frame in minute detail, we derived a statistical distribution. It showed that Lynch Radar could occasionally expect as many as 12 targets to occur along a particular radial for a particular scan, but most of the time, the maximum number so aligned was about seven targets.

While this film, of the PPI was exposed at about one frame every 9-second scan, replies from an Air Force tanker moved back and forth on an arc from about 1100 to 1300, within an open area between airways.

Over several areas, targets were distorted by ring-around and some were seen to break up temporarily. Many faded out as the aircraft landed. The highest flying aircraft and those at longest ranges present us with the longest arcs of video. This film shows dramatically how the variations in the interrogator's radiation pattern result in variable run lengths as the target passes across the beacon system coverage.

It is especially interesting to note cases where the primary-radar target fades while the beacon does not and vice versa.

When we can display all altitudes as numerics, it should be possible to direct our attention very quickly to the actual fault needing attention.

In the last sequence, black and white photography shows targets responding to the ATCBI-3 at the ARSR-2 at Elwood. That radar site is surrounded by trees. The transmitting antenna pattern is not disturbed by vertical lobing. The site is fairly well engineered. The display shows targets which are far more stable than those shown previously.

At the end of this film, we captured a rare, but real, phenomenon-- a transponder repeating its reply code many times. This is due to some fault in the particular transponder.

Well, that is the type of record we can get. If anyone is interested in pursuing the details, we can put them in touch with our photographic instrumentation personnel at NAFEC.

DIFFERENT TYPES OF TRANSPONDERS AND HOW TO USE THEM

By George H. Mahnken, NA-120 (26)

Since this is the only time that we are going to talk about transponders I thought I'd show some transponders first before we get into some of the problems.

Types of Transponders.

Figure 79 is one of the latest general aviation transponders. Its a NARCO AT-50. Its designed to meet the new MOC.

Figure 80(a) is a military transponder, a real late one - part of the AIMS program. Its the APX-72.

In Figure 80(b), notice on the fron panel of the APX-72 that we still have the carryover of the old military secure mode 2. It is still disabled on the transponder itself--the pilot does not have access to it. The control box is a miltary type control box, meant to be with the APX-72. There are many functions on it - more than you'll find with the commercial version.

Figure 81(a) is a Bendix TRU-1. This is the box that the FAA fleet is equipped with. Its a takeoff on the TRA-61 and the TRA-63. Its a commercial airline type of transponder.

Figure 81(b) is the control box for the TRU-1. It is mounted inside the cockpit for the pilot to play with.

Figure 82(a) is an AVQ-65. Its an RCA transponder. Its a commercial version, an airline type of transponder, and Figure 82(b) is the control box that goes with it. Note the small size. This is really meant for tight packing.

All of the transponders are 4096 type, capable of altitude recording.

NARCO AT-50.

The NARCO AT-50 has a function selection switch is shown on the left, and has an "off," and "standby" position, an "on" position and an "altitude" position. The "on" position is meant to be the mode 3A - the identity. When you throw the switch to the altitude position you include altitude information if its available and wired up. Press the "test" position, and there is a method for providing a test. The indicator light will light in the test mode. What's left is the 2123 four digit ID code that you can select.

APX-72.

The military aviation box, the APX-72, has a lot more buttons on it than the NARCO AT-50.

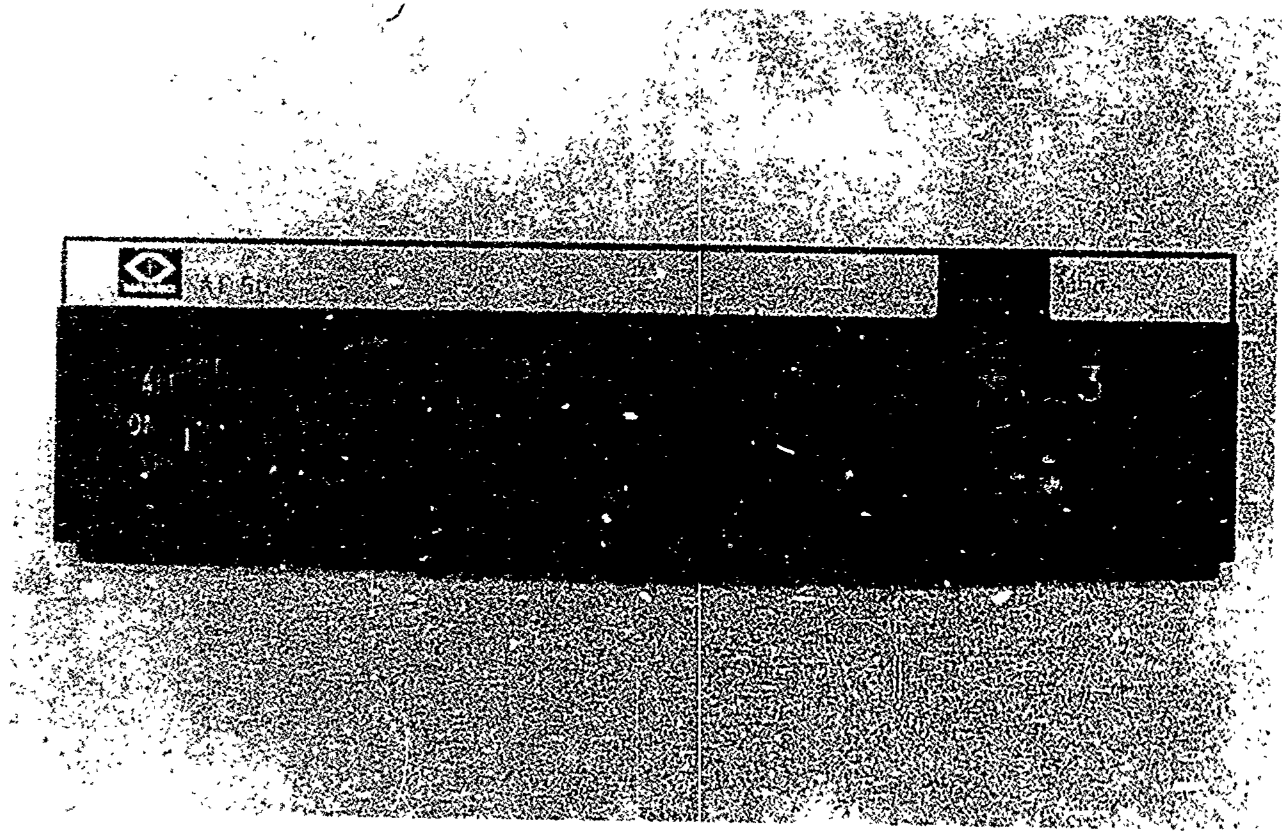
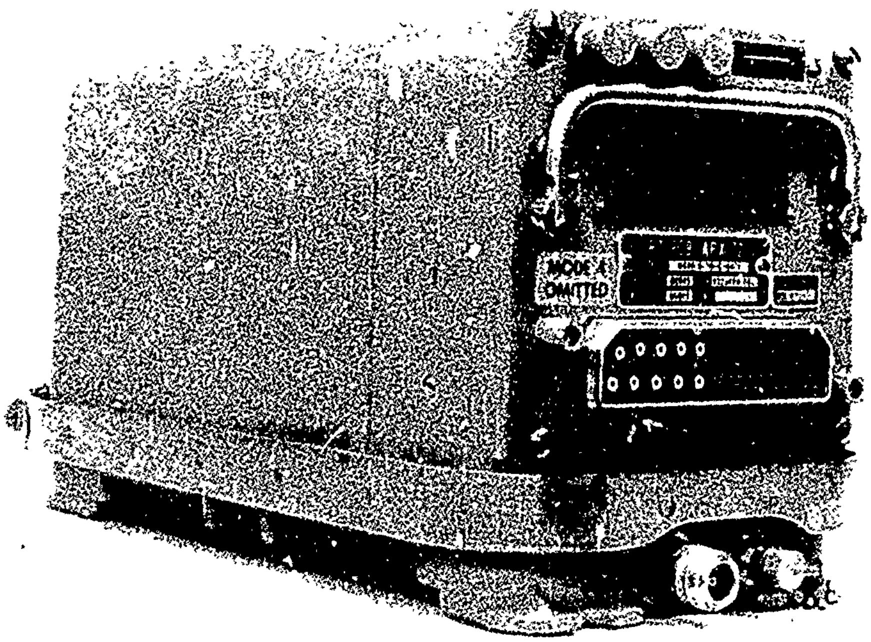
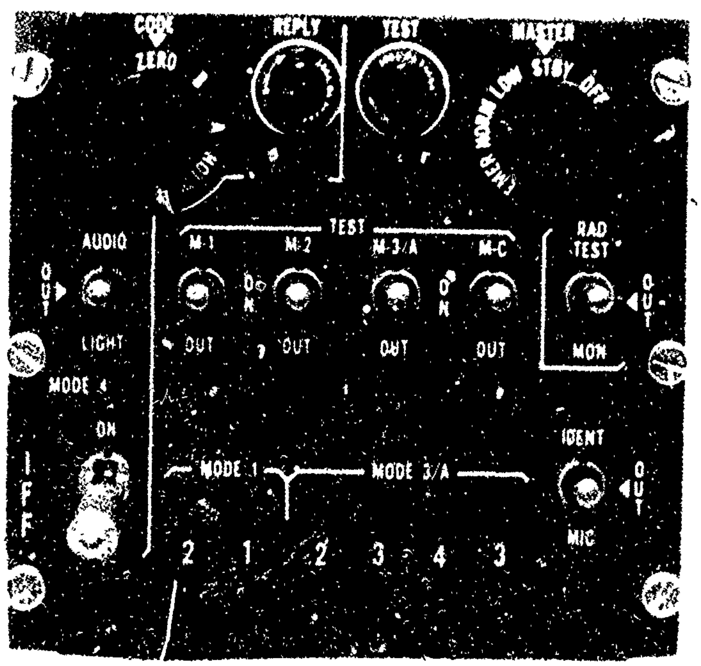


FIGURE 79. THE NARCO AT-50 GENERAL AVIATION TRANSPONDER

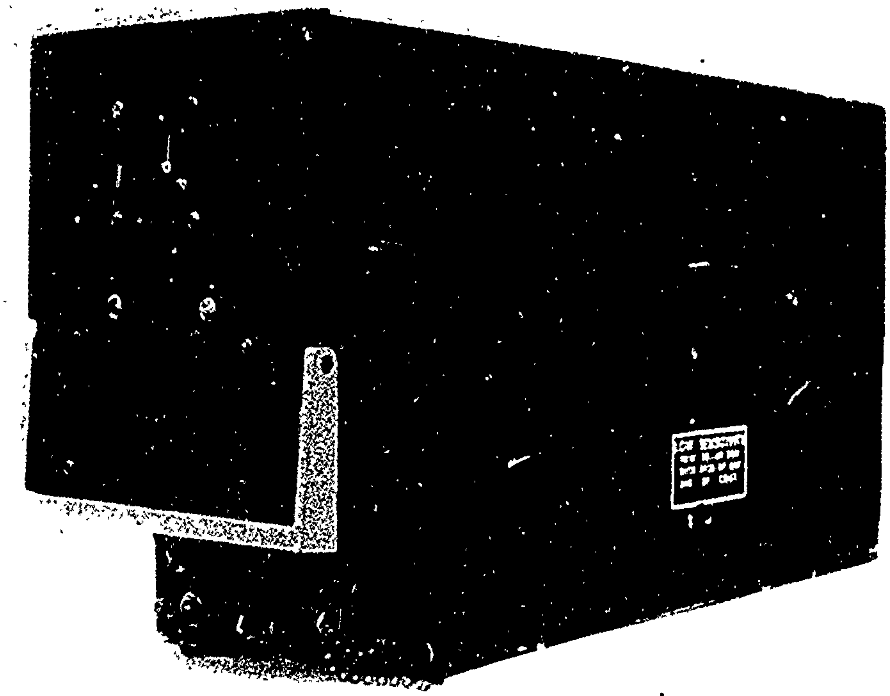


(a) TRANSPONDER

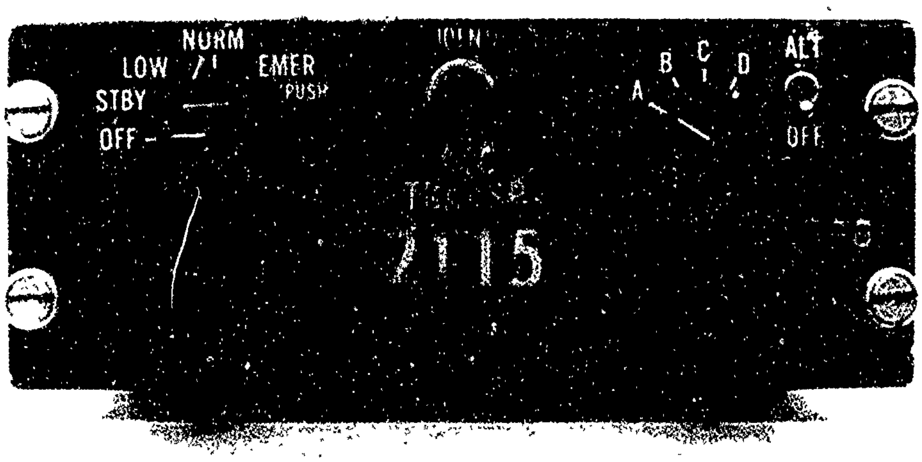


(b) CONTROL BOX

FIGURE 80. THE APX-72 MILITARY TRANSPONDER

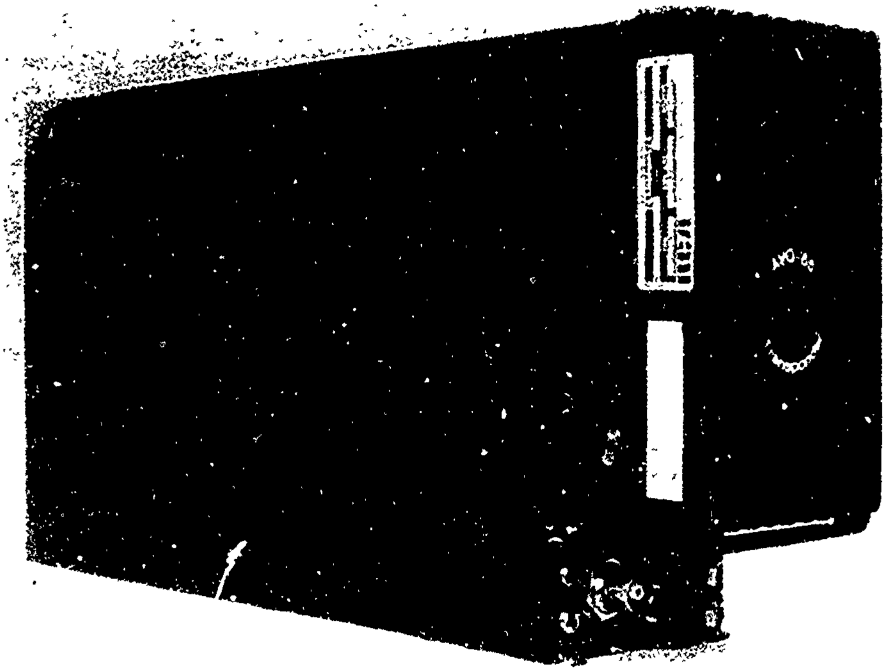


(a) TRANSPONDER

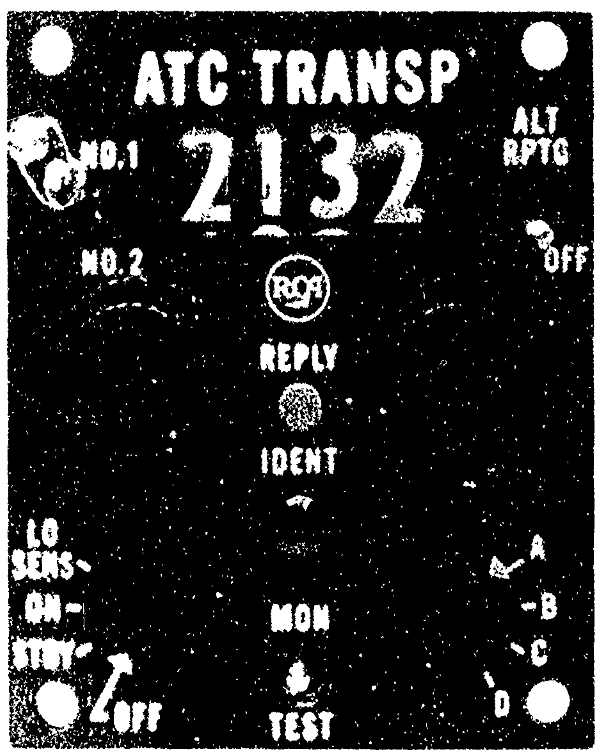


(b) CONTROL BOX

FIGURE 81. THE BENDIX TRU-1 COMMERCIAL AIRLINE TRANSPONDER



(a) TRANSPONDER



(b) CONTROL BOX

FIGURE 82. THE RCA AVQ-65 COMMERCIAL AIRLINE TRANSPONDER

The mode switches are in the center. The military does have a requirement for modes 1 and 2 in addition to 3A and C, so they have the additional capability of selecting mode 1 and mode 2 on an either/or basis, and they can select a specific code on mode 1A two digit code.

Mode 2 code is on the transponder, not accessable to the pilot. Mode 3, 4096, is separate from altitude, and there is no altitude switch, or, at least, it is not called altitude an the military control box. Altitude is that mode C switch and the altitude information is wired up into the mode C encoding position.

The function switch is somewhat similar to AT-50, the general aviation box. It has an "off" position, a "standby" position, and a "low" which decreases the sensitivity of the transponder. "Low" does not mean that the power output is decreased. In no condition is the power output ever decreased; it is always the sensitivity that is decreased.

There is a normal operating switch, and an emergency switch. The emergency switch saves twiddling a lot of knobs. You push the switch in and you go into emergency position, and this transponder will squawk emergency. There is an ident button, and there are secure functions.

TRU-1.

The TRU-1 (Figure 81) is the one that the FAA fleet is equipped with. It has the same functions that the military box does. It can select 4 digits of code. It has a function switch that can select A,B,C, or D, and we have an altitude on/off switch.

Controllers, used to talking to a military bird and saying: "Squawk mode C", if they tell this to a civil pilot, what's liable to happen is the pilot will take that mode switch and turn it up to the C position. Guess what happens. He's not going to have mode 3 anymore. He's gone out of the mode A position and he's now replying that identity to mode C interrogations. It's quite a problem.

The manufacturer doesn't like the pilot to confuse this box, so if the pilot has the mode C altitude switch on, and he has the mode C at all. Nothing happens.

AVQ-65.

The AVQ-65 (Figure 82) to the TRU-1 transponder control box, and it again has this A,B,C,D type of switch, and here the manufacturer has taken some special precautions. If you turn to mode C, you don't get anything at all - not even altitude if the altitude switch is on.

The one additional switch that is on the AVQ-65 that is not on the TRU-1 is the number 1 and 2 switch. This is where aircraft carrying dual equipments can switch back and forth.

Summary.

So what we're saying is that we have to ask pilots to transmit correctly back to controllers. The mode A is fine, we always get identity from mode A, because that's what's in the windows.

HOW TRANSPONDER ANTENNA PATTERNS CAN BE IMPROVED

By George H. Mahnken, NA-120 (26)

Transponder Problems.

The transponder does have certain bad characteristics inherent in it. One of them is dead time.

This characteristic in essence, says that the transponder cannot do two things at one time. It cannot reply, and at the same time, receive an interrogation. So it shuts itself off after an interrogation. It says its going to answer now and not listen, and it does this for a predetermined amount of time - in some cases, as short as 25-microseconds, or in the case of some military transponders, as long as 125-microseconds.

The longer this gate, the longer the transponder is shut off from the outside world, and the higher the probability that it cannot answer to your interrogation.

Side lobe suppression is another thing that does this. We want to shut the transponder off to side lobes so it shuts itself off for something like 35-microseconds ± 10, and the more times its interrogated the more times it shuts off, the more times it cannot answer your interrogation.

Another phenomenon we have is the fading and missing target, and we have several varieties of transponder mulfunction that can do this:

1. low sensitivity in the ground system
2. low power in the ground system
3. likewise in the air system

There are several more subtle things that can go on, and they have to do with echo suppression, and side lobe suppression. For example, we could lose the ditch-digger circuit, and weak P_2 pulses could come through then as we suppress the box when it wasn't supposed to be suppressed.

There are several other more subtle things too, that can go on, but I think that in getting to the fading target and the missing target problem, we really are going to zero in on the aircraft antenna, and its pattern.

Antenna Problems.

When you look at the aircraft head on, you can see various types of antenna roll patterns on existing side of the wing tips. We are not getting what we would like on an aircraft antenna, and that is spherical coverage. No matter where we put the quarter-wave stub antenna on the airplane, we are going to lose somewhere (Figures 83, 84, and 85) and this unfortunate phenomenon has resulted in attempts to somehow marry two antennas. There are several ways to do this: Unfortunately you just can't take two antennas, put them to the same transponder. If you do, you get broad lobes, and deep nulls in the antenna roll pattern (Figure 86).

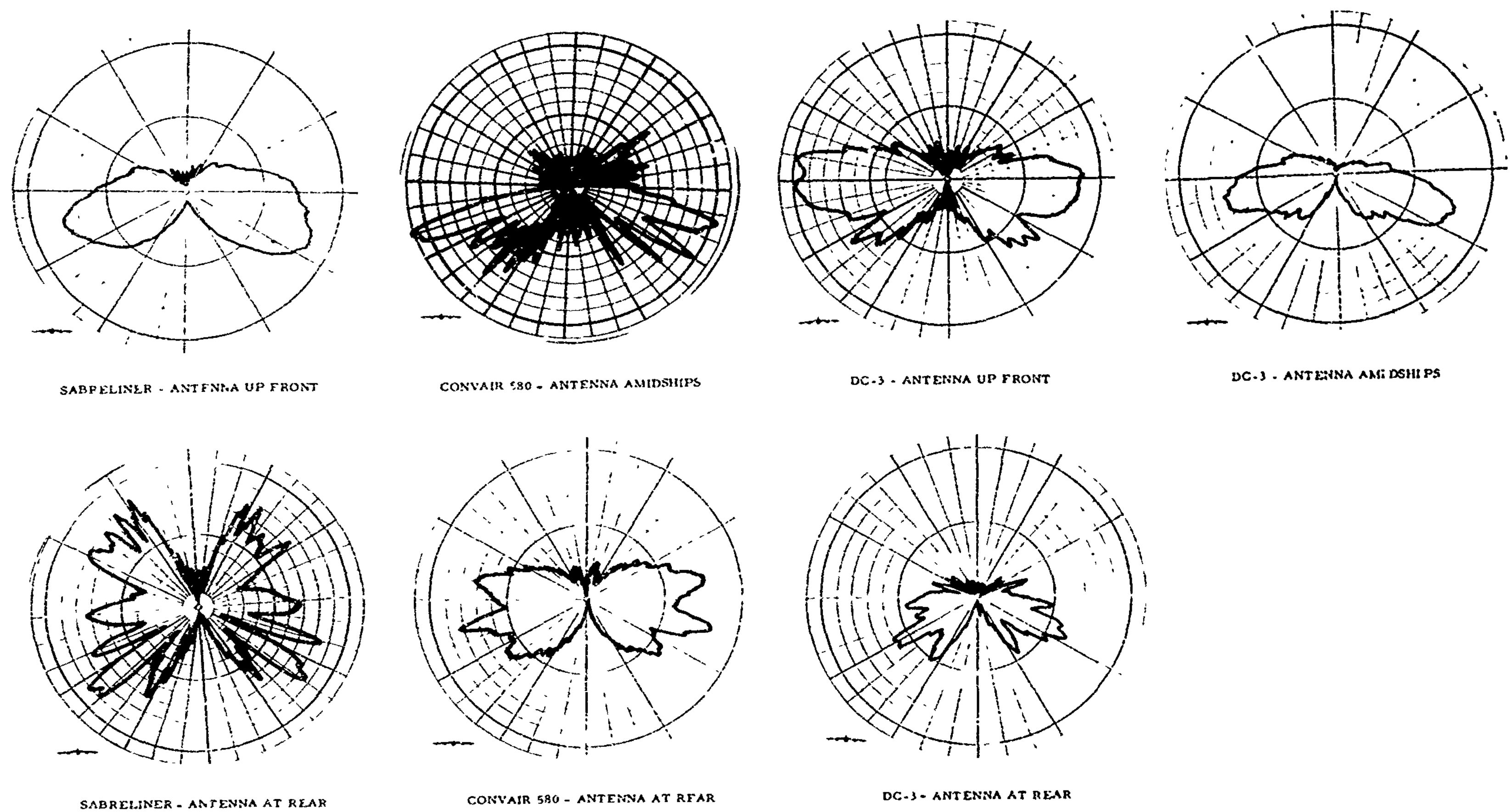


FIGURE 83. BEACON TRANSPONDER ANTENNA ROLL (HEAD ON) PATTERNS WITH QUARTER WAVELENGTH STUB ANTENNA LOCATED ON THE BOTTOM OF THREE DIFFERENT AIRCRAFT

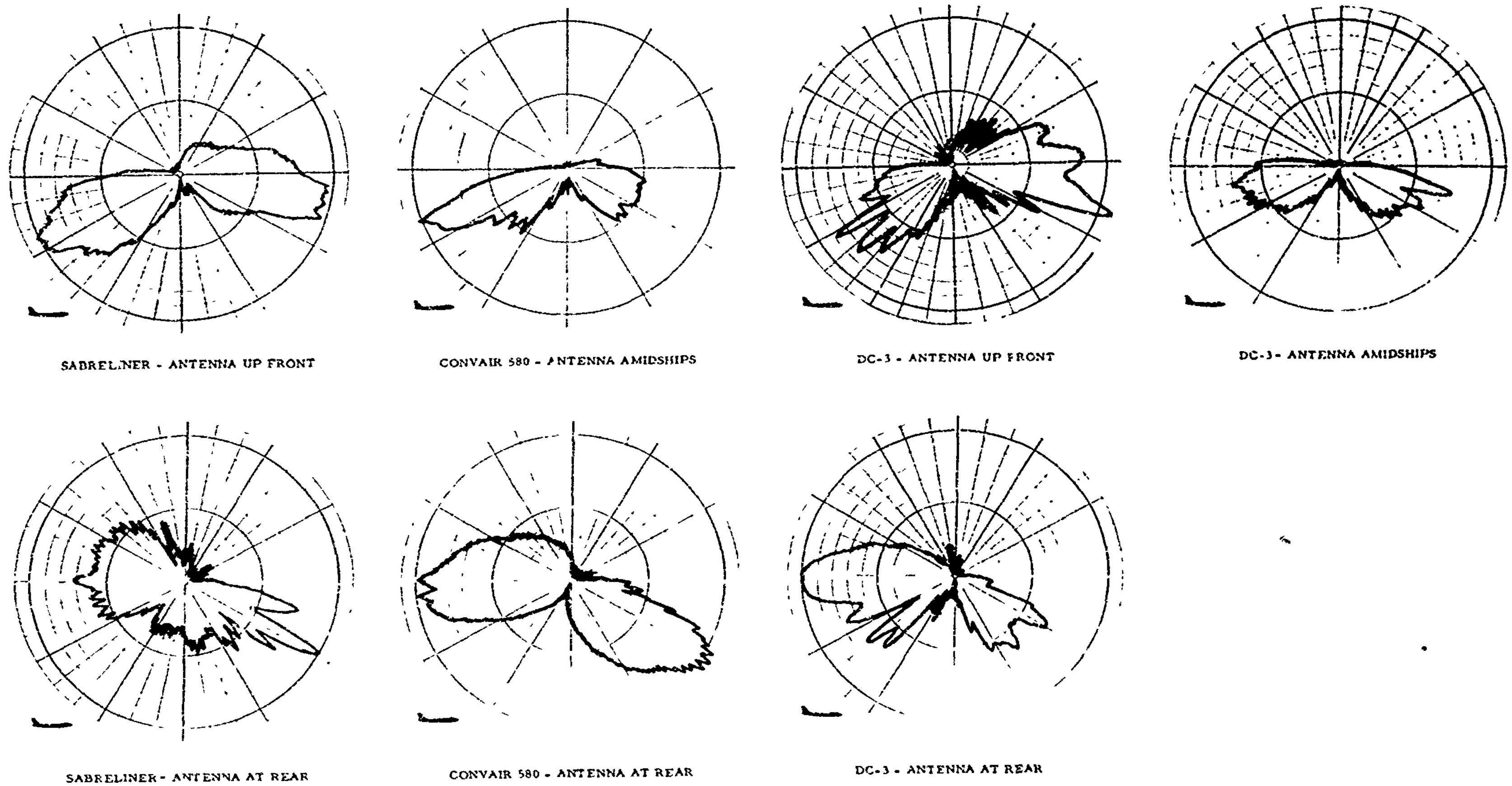


FIGURE 84. BEACON TRANSPONDER ANTENNA PITCH (SIDE VIEW GOING RIGHT) PATTERNS WITH QUARTER WAVELENGTH STUB ANTENNA LOCATED ON THE BOTTOM OF THREE TYPE AIRCRAFT

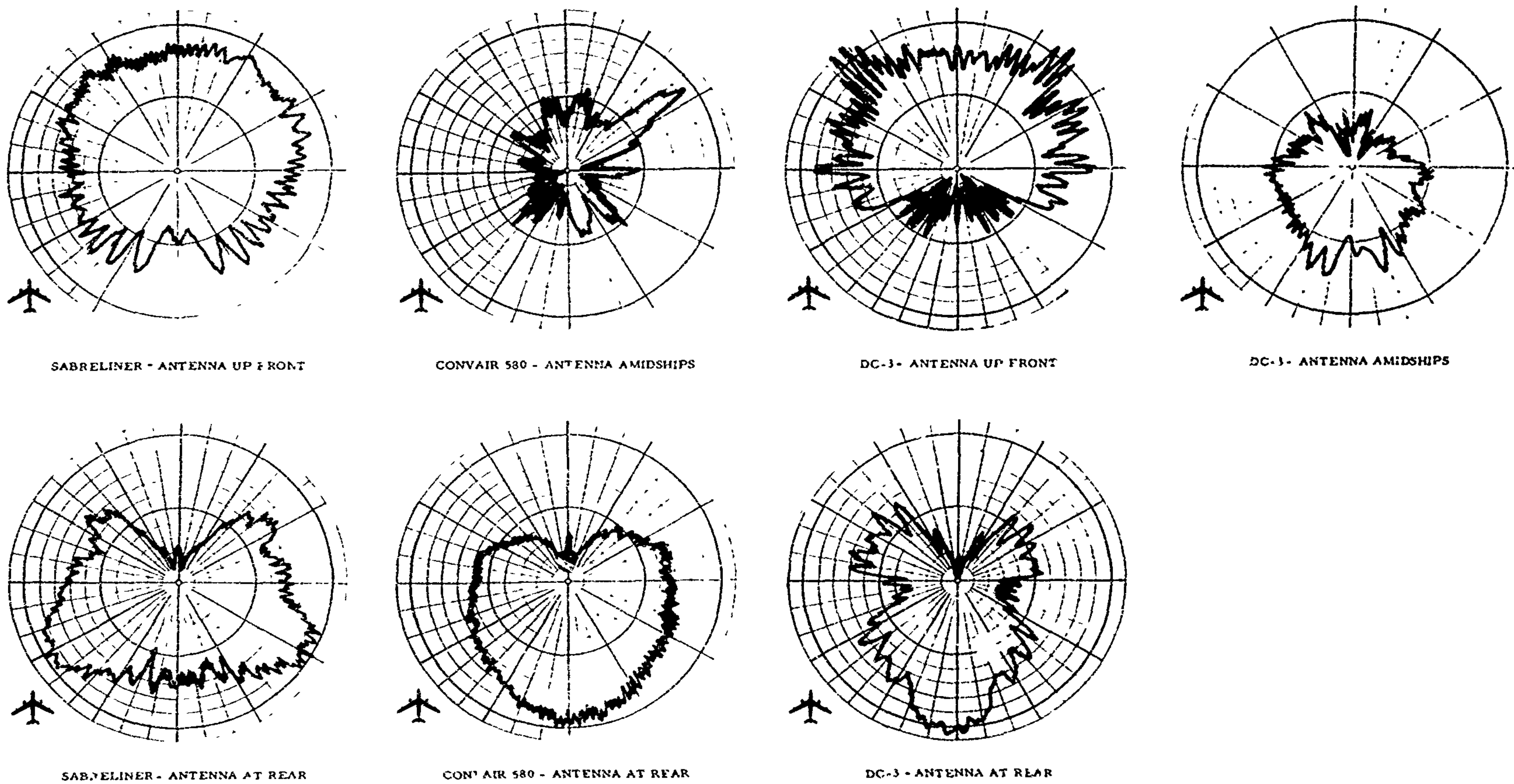


FIGURE 85. BEACON TRANSPONDER ANTENNA YAW (TOP VIEW) PATTERNS WITH QUARTER WAVELENGTH STUB ANTENNA LOCATED AT THE BOTTOM OF THREE TYPE AIRCRAFT

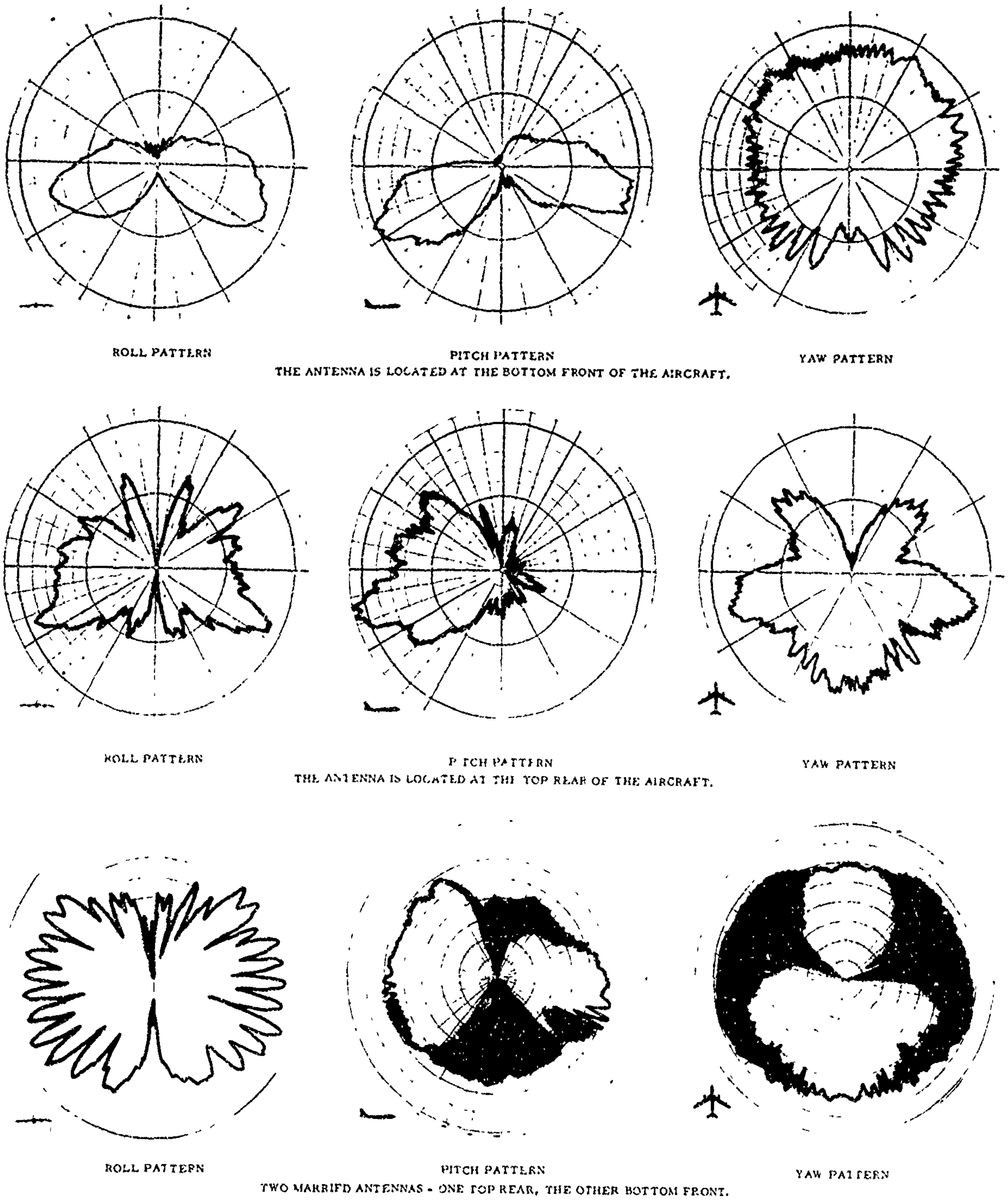


FIGURE 86. A COMPARISON OF SABRELINER ANTENNA PATTERNS SHOWING THAT MARRYING TWO ANTENNAS TO ONE RECEIVER CAUSES INTERFERENCE (DARK AREA)

Looking at the airplane sideways, we see the pitch pattern of the antenna, and there are quite a bit of lobes and nulls. The lobes are very sharp, very narrow, and generally replies from the aircraft are sporadic and erratic to say the most.

Looking at the aircraft overhead, the coverage is still unsatisfactory. Several things like this have been tried in the past. The results have not been good, and certainly not to the point where we would ever advocate doing anything like this.

Dual Input Transponder.

About two years ago, the agency did embark on a program for what we called a dual input transponder (Figure 87).

The dual input transponder tried to use two antennas, top and bottom, to take advantage of the coverage, and to marry two transponders. The difference between a normal transponder and the dual input transponder is that we're using dual receivers.

We have a sum and different circuit that tells us which antenna got the stronger signal, and from there on the rest of the transponder is the same. It has a single decoding section, a single encoding section, the lay-time encoding, the transmitter - but in essence the difference between the two transponders is that this one has two receivers, and could look at each antenna separately.

The interference pattern is no longer there. We no longer have three deep lobes and nulls, that caused us a poor operation.

We have recently completed tests on this at NAFEC, and the results are rather good. Very good, in fact.

A good deal of our tests were limited to some climbouts, where we could, with the aircraft that we used, a Gulf Stream and a Convair 880, four engine jet, and run a lot of turns and over patterns, and the results were quite good.

We got a very good increase in the coverage - to the extent that the controllers would no longer be bothered by fades when they gave the aircraft the turn, or by missing targets either.

Why Not Two Transponders.

We've tried one other approach, and that was in essence - why go through the special design of a transponder with two receivers when a lot of air carriers carry two transponders to start with. Why not hook a transponder to the top antenna, hook a transponder to the bottom antenna, and let each one play individually.

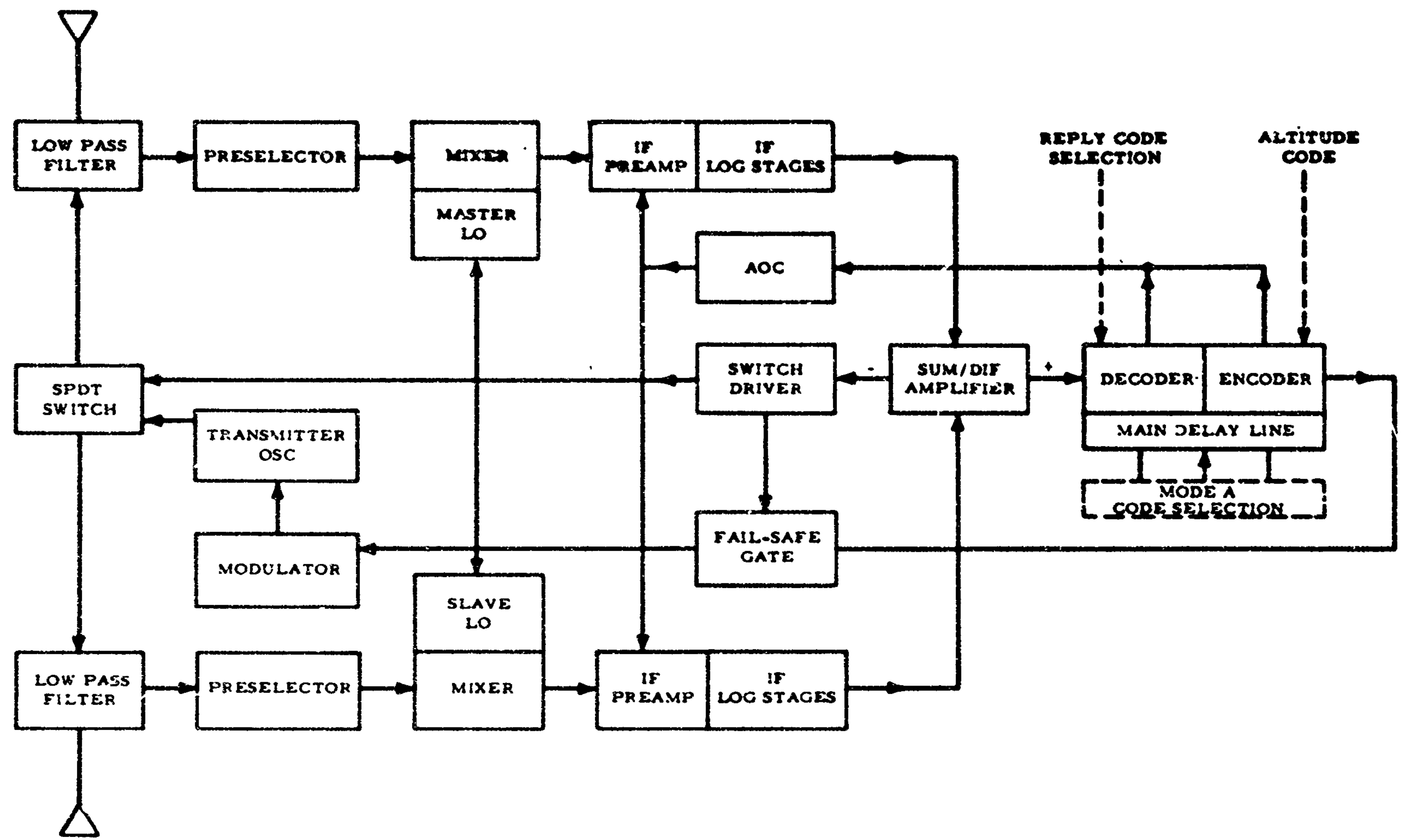


FIGURE 87. SIMPLIFIED BLOCK DIAGRAM OF DUAL INPUT TRANSPONDER (DIT)

This is about where we are now. We did some preliminary tests, and the data looks as good as the data that we got from the dual input transponder; in some respects it looks a little bit better because we do not have the dead time and the suppression time to put up with, like we do in a single unit. The top unit can operate while the bottom unit is being suppressed. In the dual input transponder this cannot happen.

So this looks like our answer to the fading and missing target problems where we are concerned with antenna problems.

SUMMARY OF THE DISCUSSION ON MISSING AND FADING TARGETS

By Thurman L. Duncan, RD-242 (23)

The problem now is the capability and means that can be utilized either administratively or technically for the elimination of missing and fading targets that exist in the operation of the air traffic control radar beacon system.

Some of the solutions to the problem of missing and fading targets that we recommend are.

1. Let us make use of all available and existing siting criteria and facilities and policies to the maximum extent. In making use of what we have now it certainly would be of help if the regions would give headquarters support in the sense that if they see a wrong direction being taken, such as RML towers and things like that, to make some objections to it, and the problem will be more readily recognizsed.

2. We should establish within the FAA, more technically extensive and complete radar siting criteria and policies.

3. Establish workable and enforceable site selection procedures with proper checks and balances so everyone is satisfied.

4. Provide portable radar beacon systems to field crews and adequate flight check facilities to survey the operational abilities of proposed sites before permanent installations are implemented.

That is essentially what I'd like to recommend as a result of this symposium.

SITING RECOMMENDATIONS

By Vincent Preston, et al, AFS-22A (20)

We thought this was one of the bigger problems pointed up in the seminar, and the three of us got together and worked up perhaps more detailed recommendations along these lines.

1. Radar siting policy and procedures do need to be drastically revised. We are all laware that siting criteria handbooks are being developed and these will be useful, but we don't believe that these are the complete answer. We feel that every new radar facility, both enroute and terminal, should be sited by a team of experts. This team should be composed of one member from each of the following:

a. Airways Facilities Service in Washington
b. Airways Facilities Division in the Region
(both electronic engineering and civil engineering)
c. The Air Traffic Division in the prospective Region

2. To expand on the siting criteria that are being developed, we feel that a complete package containing up-to-date information on details of desirable and undesirable charcteristics of site location should be available to this team.

Airways Facilities Service should develope and continue this package with inputs from R & D, NAFEC, and other sources.

3. Also, the initial cost consideration during the siting process should be secondary to the technical considerations. Management should realize that in the final analysis this should result in savings due to lessening of after-the-fact problems.

4. The siting team should have at their disposal NAFEC assistance, including specially instrumented aircrafts and vans, RFI and Frequency Management expertice, and mobile facilities, and funds for flight checking and evaluating questionable sites.

We feel that expedited action is required due to the investment envolved in ASR-7 radar program and the forthcoming ASR-3 program.

LET'S FIX THE ANTENNA FIRST

By Ralph Bishop, SM-112 (9)

While siting cannot be sidestepped in any form or fashion, we still should look at the aspects of why we have got siting problems. Why is siting so important?

It will always be important to some degree, but I don't think we're concentrating on the basic problem, this is our antenna system which is requiring a tremendous siting criteria. There has not been any improvement in this antenna, in this aspect, since the first beacon system has been installed. We've narrowed the horizontal beam width but we've not done anything in the vertical beam width.

So lets make sure in this meeting that we come up with a strong recommenda- -tion that an all out effort be made to improve the antenna, so that we n't have the siting problems that we've got, and won't have to concentrate so much, and go to so much expense in siting radars and beacons.

BIOGRAPHICAL NOTES

(1) MARTIN POZESKY, EM-20

Marty spent the first six years of his engineering career with the United States Navy. He served the Naval Ordinance Laboratory, the Naval Electronics Systems Command and the Chief of Naval materiel. He held various positions in development of a wide variety of Naval Air Traffic Control systems ranging from automatic landing and Air Traffic Navigation to radar beacon systems. He was the chief engineer for the development of the Navy's AN/TPX-42.

In 1970, Marty joined the FAA's Office of Systems Engineering Management as Technical Director for Surveillance and Data Systems, where he is currently involved in planning and implementing several key Research and Development programs, including the improvement of the Air Traffic Control Radar Beacon System.

(2) LARRY L. GRAIG, AT-120

Larry represents the Air Traffic Service within the Radar Beacon Program at FAA Headquarters. He is an Air Traffic Control Specialist in the Terminal Branch of the ATC System Requirements Division.

Larry joined the FAA in 1959 as a controller trainee in Spokane, Washington. He came to Headquarters from the March RAPCON, Riverside, California, nearly two years ago. In his principal function at present in headquarters, he is charged with understanding, identifying, and fostering the satisfaction of F & E requirements related to the ATCRBS.

Larry will appear on most of the workshop panels where he will help us assure that operational aspects are not lost in discussions of technical equipment.

(3) LT. COL. ALAN N. GOOD, USAF

Lieutenant Colonel Al Good is one of the two members of the Operation's, OP-4, who are on the Beacon Management Team.

Al takes up matters involving the military services. He coordinates all contracts about the technical and operational aspects of ATCRBS with the Army, Navy, Coast Guard, Air Force and Marine Corps of the United States and also the services of other friendly governments.

It was through his effort, that we have so many representatives of the military service at this seminar.

(4) ALTON M. WALDIN , EU-560

Alton M. Waldin is Air Traffic Advisor to FAA's Europe-Africa-Middle East Region, Headquarters in Brussels, Belgium.

Al Waldin started in traffic control during 1946 in Miami, Florida at the Miami Center. In 1958, he moved to the FAA Academy as instructor. In 1960, he went to Washington Headquarters for two years, "escaping" back to the Academy in 1962. After three years as a branch chief at the Academy, he moved to Brussels, Belgium with the new EU Region.

As "Air Traffic Advisor", Al now maintains the FAA link with European Countries in ATC and serves a NATO Committee on European Airspace Coordination.

(5) LT. COL. NORMAN F. WILLIAMS, USAF

Colonel Williams started out as a controller with the FAA in 1948 at the Jacksonville Center. He entered the Air Force in 1951, and worked with the AFCS Navaid squadrons, flight check units, and so forth, from 1954 to 1964. He was back in the Pentagon from 1964 to 1967.

After a year in Vietnam, he was assigned to his present position in the Department of Defense as one of the alternate representatives to this CEAC Committee. He is stationed at the USAF Headquarters in Wiesbaden.

Colonel Williams is the current chairman of the SSR (Secondary Surveillance Radar) group, under the CEAC. He will carry on this discussion with the technical part.

(6) JOSEPH E. HERRMANN, OP-4

Joe joined the Civil Aeronautics Administration in 1947 as an engineer in the Technical Development Center at Indianapolis, Indiana. He became involved with ATCRBS during its initial system testing and helped to develop the U.S. National standards for ATCRBS.

In 1959 he entered the Research and Development Service where he was Chief of the Beacon System Section for many years. For the past year, Joe has been on a special assignment serving as Chief, Beacon Management Team within OP-4, the Program Requirements Staff.

Listening to his workshop address on "Problems of Broken Targets and What to Do About Them," you will see that much is being done at headquarters to promote the continuous upgrading of the operational ATCRBS.

(7) AUGUST S. HALL, JR. NS-10.2

Gus started with the Agency in 1947 as a controller in the Jacksonville Center. He spent 2-1/2 years as ATC instructor at the OKC Academy, 1954 - 1957. After he went back to Jacksonville as Watch Supervisor, 1957 - 1958, he was transferred to ATS Washington in 1958 in the Plans Division.

He was then transferred to NAFEC during the latter part of 1958, and held various positions until transferring to the original NASPO Headquarters in 1964.

Gus spent 1-1/2 years in NASPO headquarters and then transferred to Jacksonville as Chief of the NASPO Field Office. During this period, he served as NASPO site representative to assist the Region and contractors in installing, testing, and commissioning of the first NAS Stage A En Route System.

(8) ANTHONY D. BRADLEY, NA-120

Tony Bradley entered the government service by way of the Eastern Region, where he spent several years installing and commissioning radar and beacon facilities. By 1963, he switched to the research and development testing and the evaluation work of NAFEC. His experience has included not only radar and beacon projects, but for several years a close involvement in the FAA studies of Collision Avoidance and Pilot Warning Indicators.

More recently, Tony has been working toward the introduction of the new Electronic Scan (E-Scan) antenna for the future beacon system. He has been giving special attention to the new program known as the Discrete Address Beacon System (DABS), into which the E-Scan antenna eventually will be incorporated.

(9) RALPH BISHOP, SM-110

Ralph started with the CAA in 1955, where he worked in the Terminal Radar Program. In 1960, within the FAA, he entered the maintenance program which supported the joint FAA/Military use of surveillance radar facilities. As that program matured, Ralph moved into the Maintenance Engineering Division where his energies have been devoted, to date, toward the improvement of both primary and secondary radars for air surveillance.

His recent consideration of possible modifications to curtail or eliminate false emergency alarms gives Ralph a unique preparation for moderating technical aspects of this workshop.

(10) JOHN P. KEMPER, WE-406

John was employed for 20 years by the Federal Communications Commission as an Electronic Engineer prior to his joining FAA in 1961.

In June, 1961 John transferred to FAA's Western Region Frequency Management Staff. There he has been responsible for developing the monitoring vehicles used in 5 regions (SAIL vehicles) and the techniques now used for RADAR at ATCRBS antenna pattern plotting and interference location. John has had considerable experience in identifying and locating sources of interference to ATCRBS.

He is presently Chief, Frequency Management and Leased Communications Staff, Western Region.

(11) JOHN H. CONDON, RM-433

John joined the CAA in 1958 as a technician at the first joint-use radar commissioned at Mica Peak, Washington.

In 1960 John was radar supervisor at Denver; in 1962 he was the subsector chief at the Denver Center. Since that time, he has been in the Radar/Data Section of the district office, the area office and the regional office.

(12) LOUIS A. KLEIMAN, TSC

Lou became involved with ATCRBS in July 1970 when the NASA Electronics Research Center in Cambridge, Massachusetts became DOT's Transportation Systems Center. He had worked as an electronics engineer for five years both at NASA/ERC and at the Manned Spacecraft Center in Houston.

He has conceived, designed, and developed a pulse-by-pulse computer simulation of ATCRBS, including graphical representation of ATC displays, during his career with TSC.

(Since the seminar, Lou has become Chief of TSC's Beacon Systems Programs Office).

(13) GEORGE F. SPINGLER, NA-120

George started his government career in July of 1948 when he joined the First Region of the Civil Aeronautics Administration in New York, New York. He managed numerous F & E projects, associated with communications, VHF links and microwave links, in the 12 years he was assigned to this area.

In 1960, George entered the Data Processing Center (DPC) Computer Supervisor School at NAFEC and transferred permanently to the Experimental Center when the DPC concept was abandoned in 1962. Since this time, he has been associated with radar beacon where much of his time has been devoted to the investigation of field problems.

George enjoys the challange that most of these field problems present and particularly the people he comes in contact with during these field visits.

(14) E. HENRY BOWEN, NA-421

Hank joined the Civil Aeronautics Administration in June of 1958 as a radar technician at Washington National Airport. He worked at several sites such as Montauk FFS-35 Site, JFK Terminal and En Route Radar Sites and Wilkes Barre, Pennsylvania.

In 1970 he transferred to the Regional Headquarters as an Electro Magnetic Compatability Specialist. To date he was the only Electronic Technician in the agency with that title or position description. Working in close coordination with the Eastern Region Frequency Management and RD-500 in Washington, he collected spectrum data and investigated radio and SECRA/RADAR interference problems.

A working knowledge of equipment operation and maintenance of the various facilities aided Hank in his discussions with facility personnel and this led to the information presented. The Electro Magnetic Compatability Specialist position has since been abolished and Hank is now in the Program and Planning Branch, Eastern Region.

(15) GERALD J. MARKEY, RD-525

All of Jery's professional experience as an Electronic Engineer has been with the FAA. He started in the Eastern Region where, for 9 years he managed numerous F & E projects. His experience has included work with radar, radar beacon, radio microwave links at various sites, and with display systems, both at Centers and Towers.

For the five most recent years, his duties have been in the Radar Section of the Frequency Management Division at Headquarters in Washington. Jerry's desk is the focal point for coordination of all government agencies that utilize the frequency spectrum for radar systems. Any problems of interference with the radar beacon system, or by it, are directed to RD-525, and Jerry is obliged to face them. You should be pleased to learn that he is ready, willing, and able to help you solve or avoid many problems in the field.

(16) MARTIN NATCHIPOLSKY, RD-242

Marty is now Chief, Beacon Systems Section in the Communications Development Division of SRDS. His professional career began at the Airborne Instruments Laboratory, in New York, where he worked on the radar beacon system. The contract involved tests and analyses of secondary surveillance radar for the CAA, and later the FAA. As a Project Engineer for AIL, he participated in evaluation tests of the first four beacon sites commissioned by FAA in the New York area. Before entering SRDS in 1963, Marty worked at the Airborne Armaments Division of Westinghouse Corporation, at Baltimore, Maryland. Under Marty's leadership, projects are now in progress which are expected to produce prototypes of advanced new (problem free) systems to replace the present ATCRBS equipment in the field.

(17) FREDERICK WONG, PC-430

Mr. Wong came to the CAA in 1956 after spending 7 years in the Air Force primarily engaged in long range radar installation and maintenance. He has worked in the NAVAIDS and Radar programs and is presently in the Maintenance Operations Branch of the Pacific Region.

(18) A. V. SHAW, AFS-22

A.V. joined the CAA in 1958 as an Electronic Technician in the Airways Facilities Sector at Tallahassee Florida. After entering on duty he began his FAA career training at OKC. This training covered a period of four years and consisted of Communications, ILS/VOR, TACAN, RADAR and TTY. In 1962 he moved to Mobile, Ala. as the Engineer In-Charge at Brookley AFB. During this time he became acquainted with the many complaints and short comings of the FAA's ATCRBS system.

In 1966, prior to the closing of Brookley AFB, he was selected as an Assistant System Engineer in the NAS system at Jacksonville Center. The NAS requirement led to a six month 9020 computer school at OKC and additional training at the Jacksonville, Center. From 1967 to the present,he has performed in the capacity known by most as the MLO. In this firing-line position he has heard the many complaints of false and broken beacons.

(19) ARNOLD BELLER, EA-432

Arnold Beller joined the Eastern Region of the Civil Aeronautics Administration in 1950. He became involved in ATCRBS in 1958, installing and testing ANDB Beacons at terminal facilities and Mark X SECRA equipment at en route radars.

For the past year he has been the principal engineer for the Eastern Region radar maintenance programs and establishment projects.

(20) VINCE L. PRESTON, AFS-22A

Vince joined the FAA in 1960 as an electronics technician at Imeson Airport Jacksonville, Florida. Three years later he entered the joint-use Frequency Diversity radar program as a Supervisory Electronic Technician at the FPS-27 radar site at Charleston, S. C.

In 1966 he was selected as one of the original entrants into the NAS Stage A implementation program at Jacksonville, Florida. For the past six years Vince has participated in all aspects of this prototype program in the position of Systems Engineer.

(21) ROBERT D. COTEY, DV-532A

Bob joined the CAA in 1957 as an Air Traffic Controller at the Denver ARTCC. He became increasingly aware of radar beacon problems while working in this capacity for 13 years. He served on the staff at the Denver Center as an Area Specialist from 1970 to 1972. While on this assignment, he participated in the radar beacon seminar at Atlantic City. Recently, he transferred to a line position at Denver Center as a Team Supervisor.

(22) ROBERT J. STUTZMAN, SW-432

Bob entered on duty in the CAA, Second Regional Office, Radar Installation Section, in 1955. During the following years he performed installation and commissioning work at ASR, ARSR, and ATCRBS facilities throughout the Southern and Southwestern states. He was assigned to the New Orleans Airway Facilities Field Office as a radar engineer in 1967. For the past two years he has been employed in the Southwest Regional Engineering Branch at Fort Worth, Texas, where he is responsible for the maintenance engineering aspects of ASR and ATCRBS facilities.

(23) THURMAN L. DUNCAN, RD-242

Thurman began his career in the CAA some 25 years ago. After 9 years of field maintenance, he transferred to Headquarters in Washington, where since 1956, he has been involved professionally, as an Electronics Engineer, with the ATCRBS Program.

While FAA had an Installation and Maintenance Service, Thurman managed the procurement and deployment of ATCBI-3 equipment. He has a rich background about the history of much of the equipment now in the field. Since 1966, Thurman has been fostering worthwhile research and development projects as a member of the ATCRBS Program Management team in the Systems Research and Development Service.

(24) FREDERICK A. LIEBE, AFS-826

Fred joined the Civil Aeronautics Administration in 1955 as a radar technician at Newark Airport, New Jersey. He became involved with ATCRBS shortly after reassignment to the NYARTCC with the installation of the ANDE System in 1957.

In 1958 he was reassigned as an engineer in the Radar System Section in the Eastern Region where he served as Chief of the Radar System Section for three years before being assigned to the New York Area Office in 1965.

Fred left the New York Area Office in 1967 to serve in his present position as Manager of Airway Facilities Sector (AFS-826) at the New York Common IFR Room.

(25) JOSEPH J. SCAVULLO, NA-120

Joe came to NAFEC in October 1968 to help build the measurement facilities. He had been in airborne radar engineering since 1943 at the MIT Radiation Laboratory as a naval officer, and as a post-war staff engineer in the Insturmentation Laboratory at MIT. His experience included five years in charge of airborne radar and display developments and five years in charge of guided missile telemetry and range instrumentation for the Navy's Bureau of Aeronautics.

Highlight of Joe's work at NAFEC include over-ocean data transfer, experiments, management staff operations, supervision of radar and beacon engineers and management of the development of the Beacon Numerics Display System. More recently, he has served as senior engineer in the ATCRBS program at NAFEC.

As chairman of the Seminar, Joe brings to the podium some 26 years of government service, professional degrees both in engineering and business Administration, and a broad variety of after-hour study and teaching assignments.

(26) GEORGE H. MAHNKEN, NA-120

After George left the U.S. Army, he pursued engineering at Brooklyn Polytechnic Institute. In 1957 he began to serve the FAA in the Eastern Region. Four years later he came to NAFEC, where he has become preeminent in the field of beaconry. Although his work has been focussed on the interaction between airborne transponders and the ground-station processors, George speaks with authority on all aspects of the system logic of ATCRBS.

During development of the Beacon Numerics Display system at NAFEC, George directed the design, fabrication and testing of the processor which was the heart of the system.

Through his careful study of digital logic and the principles of logical design, George has been able to plan and undertake developments to improve ATCRBS. Most of his efforts could only be successful through combining with modern technology the intimate knowledge he has of beaconry.

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